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WPIPER 1.0 With Flow Reduction Module

Implementation Guide and User's Manual

by
Vicki L. Van Blaricum, Richard C. Guglomo, and Vincent F. Hock

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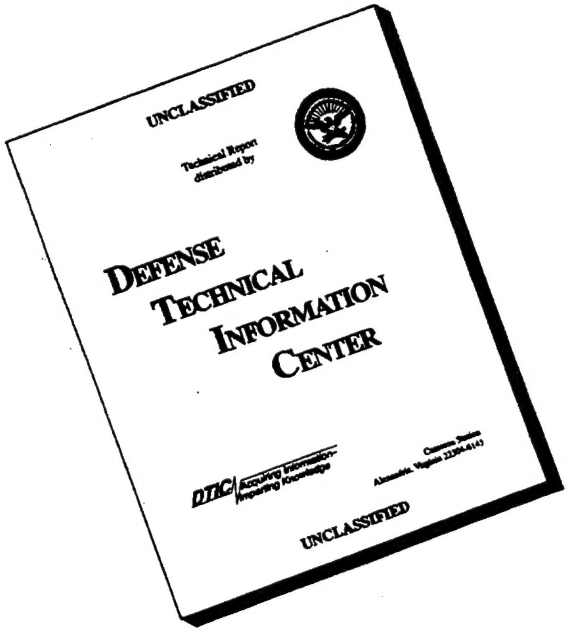

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This report describes the WPIPER 1.0 system, methods of collecting input data, and procedures for operating the program. WPIPER was developed to operate on an IBM-compatible personal computer running MS- or PC-DOS. The minimum recommended system configuration includes an 80386-based system with 640 kilobytes (KB) of conventional RAM, 2 megabytes (MB) expanded memory with an EMS driver, a math coprocessor, and a fixed (hard) disk drive with a minimum capacity of 20 megabytes (MB).

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Foreword

This study was conducted for U.S. Army Center for Public Works under Project 4A162784AT41, "Military Facilities Engineering Technology"; Work Unit FM-C44, "Water Distribution Pipe Maintenance System." The technical monitor was Malcolm McLeod, CECPW-ES.

The work was performed by the Materials Science and Technology Division (FL-M) of the Facilities Technology Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Vicki L. Van Blaricum. Richard C. Guglomo is a project engineer associated with Kennedy/ Jenks Consultants, Federal Way, WA. Ellen G. Segan is Acting Chief, CECER-FL-M; Donald F. Fournier is Acting Operations Chief, CECER-FL; and Dr. Alan W. Moore is Acting Chief, CECER-FL. The USACERL technical editor was William J. Wolfe, Technical Resources Center.

COL James T. Scott is Commander and Acting Director, and Dr. Michael J. O'Connor is Technical Director of USACERL.

Contents

List of Figures and Tables

Figures

Tables

1 Introduction

1.1 Background

A reliable underground water distribution system is essential for the daily operation of military installations. The system must be able to deliver enough water to meet the normal maximum demand at all points of use. It must also be able to supply enough water for fire suppression.

Many Army water distribution systems were constructed of unlined metallic piping (usually cast iron or carbon steel). Many such systems are over 30 years old and are significantly deteriorated. One problem that commonly occurs in unlined metallic pipes is tuberculation, which is the buildup of corrosion products on the internal pipe surfaces. Tuberculation reduces the amount of water that the system can deliver (i.e., its carrying capacity). Eventually, if proper maintenance action is not taken, the system may no longer be able to supply water in the necessary quantities and at the necessary pressures for firefighting and for normal demand situations.

Several alternatives for treating this type of problem include replacement with plastic or cement-lined ductile pipe, installation of parallel lines, pressure cleaning and lining, addition of more pumping power, or making changes to the water treatment program. At an Army installation, the Directorate of Engineering and Housing (DEH) or Directorate of Public Works (DPW) must decide when and where maintenance action is needed. The DEH/ DPW must then select the best alternative based on its life cycle cost and technical feasibility. The decision process is complex and many factors must be considered.

The WPIPER 1.0 management system is a tool that can assist the Army DEH/ DPW in making these decisions. The system includes a pipe network inventory, hydraulic modeling capabilities, prediction of internal flow reduction, prioritization, and economic analysis. WPIPER 1.0 enables the engineer to predict when a specific area of the distribution system will no longer meet fire flow requirements and to select the best remedial alternative. This report describes the WPIPER 1.0 system, methods of collecting input data, and procedures for operating the program. WPIPER was developed to operate on an IBM-compatible personal computer running MS- or PC-DOS.

1.2 Objective

The objective of the WPIPER 1.0 system is to assist Army installations in cost-effectively maintaining sufficient carrying capacity in unlined metallic underground water distribution systems through: (1) detailed system inventory, repair, and field test databases, (2) easy-to-use hydraulic modeling tools, and (3) prediction of flow restriction due to buildups of corrosion products within pipes.

1.3 Approach

Existing hydraulic modeling and corrosion prediction techniques were investigated. A mathematical model for the prediction of flow restriction in water pipes was developed in conjunction with the U.S. Army Waterways Experiment Station (USAWES). Concepts for a water piping flow management system were developed and computerized. The system incorporates complete water distribution network inventory, hydraulic flow analysis, flow prediction, and prioritization and analysis of alternatives.

1.4 Mode of Technology Transfer

It is anticipated that distribution, support, and maintenance of the WPIPER 1.0 program will be transferred to the U.S. Army Center for Public Works (USACPW), Alexandria, VA.

Additionally, users may directly download WPIPER via the INTERNET from USACERL's home page address:

http://www.cecer.army.mil/fl/utilities_ems/

or, using file transfer protocol (ftp), from:

ftp://ftp.cecer.army.mil/pub/www/utilities_ems/

2 WPIPER 1.0 System Overview

2.1 WPIPER Program Philosophy and Benefits

WPIPER is a water distribution piping maintenance management system that is designed for use by the DEH/DPW at Army installations. The objective of the program is to assist the DEH/DPW in prioritizing the allocation of maintenance and repair funds for water distribution networks to maintain sufficient carrying capacity. The piping system must be able to meet fire flow and daily water demand requirements—one of the key performance criteria used to evaluate water distribution system performance. The ability of the system to meet fire flow requirements is particularly important because it impacts the safety of occupants. Army requirements for fire flow specify the flow rates needed to meet safety requirements for various types of facilities (Military Handbook [MIL-HDBK]-1008B; Technical Manual [TM] 5-813-5). WPIPER can evaluate the present carrying capacity of a network, and can also predict its future carrying capacity. Based on this flow analysis and prediction, maintenance and replacement needs and costs can be forecast and prioritized.

WPIPER promotes a proactive philosophy for pipe system maintenance. Forward-looking maintenance strategies are carefully developed based on prediction of future problems and life cycle cost analyses rather than guesswork. WPIPER helps ensure that maintenance and repair resources are applied to the areas of the system that need them the most. This is different than the commonly-used reactive approach, which involves waiting for a problem to occur and then fixing it. The reactive approach ignores long-term planning and fails to recognize developing and ongoing problems.

The water distribution system at most Army installations consists of pipes of varying ages, materials, and design criteria. WPIPER's condition indexing and prediction capability allows these varying systems to be analyzed within a common frame of reference. The prediction model makes long-range planning easier and adds credibility to budget requests. Although WPIPER does not predict corrosion-related leaks, the repair database that is established over time can be used to discern trends regarding potential corrosion-related leaks (e.g., recurring problem areas in the system, age of pipe and type of material at time of leak, and types of failures in the system).

Another benefit of WPIPER is the ability to evaluate the technical feasibility of many types of system upgrades and to project the useful life of the improvements. Water distribution systems have typically been expanded by adding pipe just large enough to deliver the needed flow rate at the minimum specified pressure. This practice may minimize initial costs, but aging of the pipe in the new and existing sectors of the network results in gradual deterioration of flow and pressure capabilities. The system may eventually become unable to supply peak flows and fire flow demand. Analysis with WPIPER helps ensure that rehabilitation of an aging system is based on the method that has the best cost/benefit ratio, and not just the one that has the lowest initial cost.

The staggered growth of a water distribution system usually results in large numbers of drawings from various sources and a hodgepodge of records and specifications. WPIPER has the database capacity to consolidate the system records into a single concise, manageable file. The format allows for easy retrieval of specific data on selected pipe sections. The database may also be updated easily with repair records and hydrant tests.

2.2 System Requirements

WPIPER 1.0 was developed for operation on an IBM-compatible personal computer that runs MS-DOS or PC-DOS. An 80386-based system or better is recommended for best performance. The program system will run on an 8088 or 80286-based computer, but will have extremely poor performance because of the size and sophistication of the program. A minimum of 640 kilobytes (KB) of conventional RAM and 2 megabytes (MB) expanded memory with EMS driver (such as QEMM386 or equivalent) is recommended for best performance. More expanded memory will improve the program's performance. A math coprocessor is required to run the hydraulic analysis portion of the program. A fixed disk drive (hard drive) is required with a minimum capacity of 20 megabytes (MB). A color monitor is not required, but is recommended for the highest quality display of the program screens. Additional software is not required to run WPIPER.

2.3 WPIPER's Major Components

The major components of WPIPER 1.0 are: (1) databases that describe the system and store test data, (2) a hydraulic analysis module, (3) a prediction model that forecasts the deterioration of the pipe's carrying capacity, and (4) a series of informative and analytical reports. These components are discussed in the following sections.

2.3.1 *The WPIPER 1.0 Databases*

WPIPER's hydraulic network model requires complete physical information about the piping network (such as pipe section lengths, node elevations, valve settings, pipe diameters and pressures). WPIPER contains several databases that define the network and contain the information needed by the model:

- pipe section database
- node database
- appurtenance database
- pressure zone database
- tank database
- contractor database.

When WPIPER is implemented, the water distribution system is divided into discrete pipe sections. Information is gathered about each section and is stored in the pipe section inventory database. Information on the system nodes, appurtenances, and tanks is entered in the appropriate database. WPIPER also contains several databases that contain information on periodic testing and repairs:

- water quality database
- hydrant test database
- repair database
- repair costs database.

The water quality and hydrant test databases contain information used by the prediction model. The information in all of the testing and repair databases can be used to analyze trends in system failures, as well as system performance.

2.3.2 *The WPIPER 1.0 Hydraulic Model*

The WPIPER Program was designed to incorporate the AWADISO water distribution system hydraulic modeling program (Engineer Manual [EM] 1110-2-502), which was developed at USAWES. AWADISO is a public domain program written in the FORTRAN/2 programming language. AWADISO has been integrated into WPIPER so that database information and calculated results can be easily transferred between programs. WPIPER translates the information from its databases into a form that AWADISO can understand. WPIPER takes the output generated by AWADISO and formats it into a report. The exchange of information between the two programs is transparent to the WPIPER user. The user will not see AWADISO during a typical WPIPER session.

AWADISO computes pressures at the system nodes, flows and head losses in the pipes, flow and head for each pump, and mode of operation for each pressure reducing valve and check valve. The model can be used to simulate the performance of the distribution system under various conditions, such as normal daily demand, peak seasonal demand, or fire demand at a particular location. Once the behavior of the existing water system is mathematically defined, the program allows proposed system changes to be simulated. For example, the installation of additional piping, new booster pumps, or new water sources can be tested for technical feasibility.

2.3.3 *The WPIPER 1.0 Prediction Model*

WPIPER combines the water system analysis and optimization features of AWADISO with flow reduction modeling and prediction capabilities to provide a powerful tool for managing water distribution systems. The prediction model in WPIPER forecasts the effect that internal (water-side) corrosion will have on the carrying capacity of each individual pipe in the water distribution network. Because corrosion causes increases in roughness of the interior walls, head losses increase and the carrying capacity of the system decreases. As head losses increase, the amount of energy required to pump water through the system increases, thereby increasing operating costs. Eventually, certain areas of the system may no longer be able to meet demand requirements. The prediction model in WPIPER forecasts this type of problem and so helps to forecast expenses and budgeting for capital improvements.

More specifically, the model in WPIPER predicts the decrease in the Hazen-Williams C-factor (Williams and Hazen 1920) over time. The C-factor is directly proportional to the flow rate in a pipe and is commonly used in the calculation of head losses. The model uses water chemistry data and information from C-factor tests conducted in the field to predict future C-factors. The model is valid only for unlined ferrous metallic pipes that convey waters with a negative Langelier Index. The C-factor degradation model was developed by USACERL in conjunction with USAWES and has been documented previously (Walski, Sharp, and Shields 1988). A brief description of the model is in Appendix A.

2.3.4 *WPIPER Reports*

WPIPER produces a wide variety of reports that can help the DEH/DPW manage the water distribution system. The reports can be divided into two general categories: those that simply retrieve data from the databases and those that perform calculations and/or analyses. Reports that retrieve data from the databases allow you to print data about system components, including pipes, nodes, and appurtenances. Repair records, results of water chemistry testing, and results of hydrant flow testing can also be

retrieved and printed. Analytic reports provide information about the hydraulic analysis of the distribution system, prediction of future flow capabilities, prioritization of pipe sections for repair or replacement, and economic analysis of repair/replace alternatives.

3 Procedures for Implementation and Data Collection

This chapter presents a step-by-step procedure for implementing the WPIPER system at an Army installation.

3.1 Step 1: Collect Existing Maps and Records

The first step in implementing WPIPER is to collect the available drawings, maps, and records of the water distribution system. The drawings and maps should provide most of the required pipe section data. The maps should also show valve box and fire hydrant locations for ease in planning C-factor tests. The maps may also be able to provide node elevation data. Water system records may contain water usage data, repair information, installation dates, water quality data, and hydrant test information. If water usage information is not available at an appropriate level of detail, you will need to find out the building type (e.g., family housing, administration, medical, etc.) and approximate area of each building or group of buildings in the study area. You should be able to find this information in the installation's real property records.

Some possible sources for distribution system maps and drawings include:

- Base Engineering Office
- Corps of Engineers District Office
- Consulting Engineer's Office
- Installation Contractor's Office
- DEH/DPW Operations and Maintenance Division or Branch
- Local Engineering Authority.

3.2 Step 2: Prepare System Map and Assign Identifiers

The hydraulic modeling algorithm in WPIPER uses standard methods already well documented in the literature (Walski 1984; Engineer Technical Letter [ETL] 1110-2-297). Users who are unfamiliar with hydraulic modeling should consult these publications.

Before the WPIPER input data can be prepared, the water distribution system must be broken down into links and nodes. The easiest way to do this is to prepare a system map. You may wish to mark up an existing water distribution system map, or to draw a simplified or skeletonized map by hand or on the computer. Appendix B shows an example of a skeletonized map.

A link (as defined for the modeling program) may be a pipe, a pipe with a check valve, a pump, or a pressure reducing valve (PRV). There is usually a change in head between the starting and ending points of a link. A node is a connection point where two or more links come together and where water may be added or withdrawn. Water may be added at an input node or withdrawn at an output node. Nodes that have no inputs or outputs are usually designed as output nodes with an outflow of zero. It is easiest to first identify the location of pipe sections. A pipe section must meet the following criteria:

- The entire section of pipe must be constructed of the same material.
- The diameter must be constant throughout the pipe section.
- The entire section should have been installed at the same time.
- The pipe section may start or end at a pump or pressure regulating valve but should not contain such devices.
- The pipe section may contain a check valve within its length. The direction of flow is designated by the FROM/TO Node data.
- The pipe section should see the same water quality throughout its length, regardless of flow direction.
- Service connections of 2 in. (1 in. = 25.4 mm.) or less may connect at any point through the section, but larger connections should be designated at the end of a pipe section.
- A pipe section must end and a new section begin where a fire hydrant is located.

Review the maps and records to determine if any pipe sections have been abandoned. Abandoned pipe sections should not be included in the model.

Assign each pipe section a unique number between 1 and 600. This "Link Number" is used for identification purposes by the AWADISO module. Assign a Link Number to each of the identified pipe sections and mark it on the map.

AWADISO uses Link Numbers when it performs the hydraulic analysis calculations, but Link Numbers are meaningless unless you have a system map. To make data retrieval and interpretation of reports easier, WPIPER allows a more descriptive 15-character PIPE IDENTIFIER to be assigned to each pipe section. One possible pipe identification scheme involves the use of street names to specify the location of the

section. In this scheme, the location of a pipe section is described from the nearest permanent reference point, such as the intersection of two streets. Because most underground utility lines follow streets or roads to take advantage of existing easements, the Pipe Identifier will usually contain street names or abbreviations. Where streets are oriented north to south and east to west, the water distribution system will also be oriented on the compass points. Using a single letter to designate compass direction, and a three-letter abbreviation of street names, a simple Pipe Identifier Key can be derived. For instance, a pipe running along the south side of Oak Street, easterly from Third Avenue, might be assigned Pipe Identifier SOAKE3RD. The remaining seven spaces in the Pipe Identifier field are available for further identification. You may wish to mark the Pipe Identifiers on the system map.

Next, locate and assign Link Numbers to other types of links, such as pumps and pressure reducing valves (PRVs). When a pump is described as a link, it is usually given a nominal length of 1 ft (1 ft = 0.305 m), with a node on the suction side and node on the discharge side of the pump. A pressure reducing valve (PRV) is also a link, and is given a length of 1 ft with nodes on either side. Make sure that the upstream and downstream node designations for PRVs are correct. If these designations are reversed, the program will give incorrect results.

Assign each node a unique number between 1 and 400. This is called the Node Number. A water reservoir or storage tank is treated as a special input node with a set pressure head. The input flow is determined by the computer program based on demand and pressure losses.

Every system must have at least one "fixed grade node." A fixed grade node is one that will supply as much water to the system as required at a fixed elevation above the node elevation. In most cases, this will be a reservoir with a fixed water surface elevation. This could also be a supply pipeline from a water source such as a river or well. Even though this fixed grade node is a pump in the case of a well, the data should still be entered as a node with a fixed elevation. Consult the recommended references on hydraulic modeling for further information on assigning fixed grade nodes (ETL 1110-2-297; Walski 1984).

3.3 Step 3: Gather Data From Maps, Drawings, and Records

The next step is to collect the data that describes each of the links and nodes that you have identified in the previous step. Data sheets (Appendix B) have been developed to assist in this process. Data should be collected for each of the following:

- pipe sections
- pumps
- pressure reducing valves
- nodes
- appurtenances (valves, meters, hydrants).

Explanations of the pipe database fields are given in Appendix B. Some of the database fields *must* be filled in for each element if you wish to perform hydraulic simulations or condition prediction. Otherwise, the program will not operate properly. The required fields are indicated by an asterisk (*) on the data sheets in Appendix B. WPIPER also contains many database fields not specifically required for simulation or prediction, but which are useful for other functions such as tracking system repair history and costs, recording causes of pipe failures, serving as a repository of soil and water chemistry information, or providing procurement information on system components (such as the manufacturer and stock number of a valve).

When assigning valve identifers, it is best to use the valve numbering system found on the plan drawings. This will avoid confusion caused by having two ID numbers for a single item. During field surveys, look for stamped brass numbering tags attached to valve wheels or stems. The tags are used on many systems and will help you locate the valve on the plans and verify its location.

3.4 Step 4: Estimate Water Usage

The next step is to assign water demands to the individual nodes of the water distribution system. The methods for doing this have already been well documented (Linaweaver, Geyer, and Wolff 1967; Clark, Viessmann and Hammer 1977; AmericanWaterworks Association 1975). Army-specific procedures have also been developed (Bandy and Scholze 1983, Langowski et al 1985; Boland, Baumann, and Dziegielewski 1981).

Because water usage fluctuates with factors such as the season and the time of day, you will probably have many different demand scenarios. As a minimum, you should determine average normal demands and average peak demands. Depending on the water use patterns at your installation, you may wish to perform these analyses with seasonal data (e.g., average normal winter demand, average peak summer demand, etc.) You may also wish to simulate fire flows at various locations in the distribution system. Guidance for determining the required magnitude of fire flows can be found in Army Technical Manual [TM] 5-813-1 and TM 5-813-7.

3.5 Step 5: Collect Field Data

3.5.1 *Collection of Initial C-Factor Data*

When WPIPER is initially implemented, pipe roughness data (C-factors) should be obtained by field testing for as many sections of pipe as practicable. An important difference between C-factor testing and ordinary hydrant fire flow testing is that the flow in C-factor testing must come from a single pipe. C-factors cannot be calculated with data from fire flow tests because the hydrant draws water from two directions. The two flows contributing to the tested hydrant flow are unknown, hence the velocity term needed for C-factor calculation is missing.

Use the system map and the pipe section data to select sections for C-factor testing. You must be able to isolate each test section from the rest of the system such that *all* the water flowing through it enters at the beginning of the section and exits at the discharge hydrant at the end of the section. Pipes that intersect the test section must be able to be valved off so that water cannot enter it from pipes that intersect it. Each test section must have at least two locations (usually hydrants) along its length where pressure gauges can be mounted to measure the static and residual pressures. Each section should be of a consistent diameter along its length. Since it is usually not practicable to test every section of pipe in the system, try to select sections of various diameters, materials, and ages so that the widest possible range of piping in the system is represented. For example, if your system consists of 4, 6, 8, and 10-in. cast iron piping installed in 1940 and 8-in. cast iron installed in 1960, try to test at least one section of each.

After you have identified the C-factor testing sites, visit them to verify the location and accessibility of the valves and hydrants to be used. For example, valves may have been paved over and you may need to select a different section for the test or a different way of isolating it. This initial survey will save time when the full test crew begins work.

Each hydrant location should be examined to ensure a flowing hydrant will not cause a traffic jam, erosion problems, or some other similar situation. Over 1,000 gallons per minute (GPM) may be discharged from the hydrant during testing. The force of the water is formidable even at a distance. Although the testing takes only a few minutes, the considerable volume of water must drain somewhere. At each hydrant location, the following questions will assist in planning the test:

- Which direction are the 2½-in. nozzles directed?
- What ground surface will the water discharge hit?
- Will the force of the water strike any objects that may be damaged?

- Where will the water drain?
- Will the testing interrupt vehicle or pedestrian movement?

The force of the water is capable of blowing down fences and gouging holes in lawns and gardens. Utility vans are sometimes used to block the discharge of a hydrant onto the street. In areas of high pressure, a vehicle may be pushed sideways by the force of the water stream. Human safety is of paramount importance during testing, and property damage should be avoided.

The location of shutoff valves should also be verified during the pre-test survey. If fire control valves are to be operated, a padlock key may be requested from the local fire department or from the property owners if valves are located on an easement. The fire department officials may require that a representative from the fire department be present during the testing to verify that valves are locked after the test is complete. After the initial field survey is complete, the field testing can be organized and scheduled.

Appendix C contains a more detailed explanation of the steps that must be followed for C-factor testing. Additional information may be found in other publications (ETL 1110-2-297; Walski 1984).

Always take proper safety precautions during C-factor testing. As noted above, the test crew must be aware of the powerful force of the water being discharged. Another potential safety hazard is the presence of corrosion products, rocks, or other debris entrained in the flow of water. The high flows often dislodge corrosion products or scale from the interior pipe surfaces. New construction or hookup activity may result in rocks and other heavy debris in the piping system. When these materials are propelled from the hydrant orifice by high velocity discharge, they cannot be seen. Carefully examine the discharge water for entrained solids before attempting to measure the flow with a Pitot tube. Sometimes it is necessary to flush the line for several minutes to clear up the water. Watch the edge of the runoff stream where the water slows and sand and rocks settle out and are visible. *Never* allow anyone to touch or block the water stream at the hydrant.

Valves and hydrants should be opened and closed slowly to avoid water hammer. Valve stems should have a springy feeling when closed. Valves with a "dead" feeling may have a broken stem or damaged seat. In very old systems, it cannot be assumed that, just because a handle turns, the valve plug is moving. No resistance or high resistance during valve operation also indicates inspection and repairs may be necessary. The testing process is an opportunity to inspect the distribution system

valving for future maintenance activities. You may wish to keep a daily log to record any problems that are observed.

3.5.2 *Collection of Water Quality Data*

Water quality data is required for WPIPER's C-factor prediction model. Water quality data needed for the implementation of WPIPER is listed on the Water Quality Data Sheet in Appendix B. This information should be gathered for each source of water. If there are several wells that provide the water supply, data should be obtained for each well. The water analyses of the sources may be compared with point of use water analyses to determine which sources dominate a distribution area.

The base hospital or water treatment plant is a possible source of water quality data. If all the necessary information is not available, you will need to obtain water samples and have them analyzed. Proper water sampling is important to the accuracy of the laboratory results. Samples should be collected in sterile plastic bottles and capped immediately. Because water demand may affect the water quality in a looped distribution grid, sampling during peak flows should be avoided. Dissolved carbon dioxide, dissolved oxygen, and pH should be measured on-site because these values will begin changing almost immediately after the sample is collected. If your installation does not have the facilities to perform testing, the samples may be tested by an outside laboratory. Local laboratories may provide a technician to do the field sampling, which assures that samples are collected properly.

3.5.3 *Collection of Soil Samples (optional)*

Soil samples representing the various types of soil can be collected and chemically analyzed. This information is not used in the WPIPER prediction model, but is valuable information for analysis of leak and break trends, and is also useful if cathodic protection is planned or currently installed. Soil data for most Army installations are available in corrosion reduction survey reports from the U.S. Army Center for Public Works.

Samples should be collected in sterile sealable jars or in plastic "ziplock" bags. It is recommended that the samples be stored in a cooler with blue ice cold packs to preserve the moisture content of the sample. The containers should be sealed tightly and shipped to a testing laboratory as soon as possible after sample collection. The following parameters may be stored in the WPIPER program:

- soil moisture (%)
- soil sulfide content (mg/kg)

- soil pH
- soil resistivity.

3.5.4 *Hydrant tests*

A hydrant test is usually conducted in conjunction with the local Fire Marshal to determine the ability of distribution system to deliver the amount of water required for fire suppression. A data sheet to assist in collecting this information is in Appendix B. Detailed procedures for conducting hydrant tests are given in some of the previously referenced publications (ETL 1110-2-297; Walski 1984).

3.6 Step 6: Input Information into WPIPER and Generate Reports

After all of the information has been gathered, it is ready to be input into the program. Operation of the program is described in detail in the remaining chapters of this report. After the data have been entered, reports and economic analysis of maintenance and repair options may be generated.

3.7 Step 7: Maintain the Databases

After initial data are entered into WPIPER, the next step is to keep the databases updated to reflect the current status of the piping system. This way, accurate reports can be generated at any time. A system of regular reporting should be instituted so that all needed data are provided. The person responsible for maintaining the databases should monitor the following activities:

- pipe breaks or leaks
- valve repairs and additions
- pressure regulating valve adjustments
- new construction and demolition
- pipe cleaning and relining
- repair costs, including damage litigation
- water source changes
- water quality changes
- demand changes and fluctuations.

DEH/DPW personnel performing routine maintenance should be trained to identify activities that need to be recorded in WPIPER. If maintenance is performed by a contractor, the DEH/DPW project supervisor should keep records of any changes

affecting the water system. Information on these activities should be input into the database as they occur so the database will always be current and analyses can be run with confidence.

4 Software Installation and Quick Start

4.1 Conventions Used in Manual and Software

1. Throughout the remaining chapters of this document, data that is to be entered by you, the user, will be shown in **underlined bold print.**
2. During WPIPER data entry, pop-up screens will display information about the field in which data is being entered. The pop-up screens will specify whether or not the data is specifically required by the program. If it is not, you may leave the field blank.
3. During WPIPER data entry, all single key inputs (such as selecting a numbered item from a menu or answering a Y/N [Yes/No] prompt) do not require you to press the **ENTER** key. All multiple character inputs and all field entries on a full-screen edit, however, do require you to press the **ENTER** key at the end of the entry.
4. The data entry field size is indicated by the size of the field highlight.
5. All numeric fields will be aligned "flush right" by the program. All alphanumeric fields will be aligned "flush left" by the program.

4.2 Explanation of Keys Used in WPIPER

There are three types of keys available for use throughout WPIPER:

1. Editing keys
2. Scrolling and cursor movement keys
3. Function keys.

If you wish to see a list of the keystrokes that can be used at a given location in the program, press the **[F2]** key. This function is available on most screens throughout WPIPER. To determine if the **[F2]** function is available at a given location, consult the function key menu at the bottom of the screen.

Editing keys are used for editing input fields. Table 1 lists the editing keys that are available and their uses. Scrolling and cursor movement keys are used to move within an input field or between input fields. Table 2 lists the scrolling and cursor movement

Table 1. Editing keys.

Key	Function
Backspace	Backspaces and deletes a character.
Delete (Del)	Deletes character at cursor.
Insert (Ins)	Toggles between insert and overwrite.
Escape (Esc)	Erases the input field and returns to beginning of field.

keys that are available and their uses. Several of the function keys are active at certain times in the program. The function key line at the bottom of each screen displays the keys that are active for that screen. Table 3 lists the function keys and their uses.

4.3 On-Line Help

WPIPER contains on-line help, which is accessed by pressing **[F1]** at any point in the program. The help screen that corresponds to the task you are performing will be displayed. You may page forward and backward through the help screens to view related information. The information that is displayed on all of the help screens is

Table 2. Scrolling and cursor movement keys.

Key Name(s)	Function
Page Down (Pg Dn)	Displays Next Page
Page Up (Pg Up)	Displays Previous Page
Down Arrow	Moves cursor to next field
Up Arrow	Moves cursor to previous field.
Left Arrow	Non-destructive backspace
Right Arrow	Non-destructive forward space
Home	Moves cursor to start of field
End	Moves cursor to end of field
Ctrl- Left Arrow	Moves cursor to previous word.
Ctrl- Right Arrow	Moves cursor to next word.
Enter	Moves cursor to next field. If the cursor was on the last field, the edit concludes.
Tab	Moves cursor to next field.
Shift -Tab	Moves cursor to previous field.
Ctrl -End	Moves cursor to last field.
Ctrl -Home	Moves cursor to first field.

Table 3. Function keys.

Key Name	Symbol	Function
Help	F1	Displays context-sensitive help
Keys	F2	Shows available key usage
Add	F3	In Set Database Query: adds a query sort option In Data Specification Report: Adds a specify field or specify index field In System Utility Editors: Adds a blank Record to the system databases and begins edit of the field
Delete	F4	In Data Specification Report: Deletes a specify field or specify index field In System Utility Editors: Marks a record for deletion from the system database. F4 is a toggle to delete and undelete marked record
Edit	F5	In Set Database Query: Selects a field's condition for inclusion in the report In System Utility Editors: Edits the current highlighted field
	F6	Not used.
Sort	F7	Sort records in System Utility editors
Compute	F8	Transfer calculator value to field
List	F9	Bring up list of values and select
Done	F10	Exit from screen or prompt

stored in the WP RPT.HLP file. You may print this file using a word processor if you wish to have a hard copy of the information that is contained in the on-line help utility.

To select a topic from the Help Index (Figure 1), use the cursor keys or the space bar to position the highlighted selection bar on it, then press **[Enter]**. The help screen will be displayed. The help messages are usually longer than one screen and may be scrolled vertically using the cursor keys. A sample screen showing the top of the AWADISO - TERMINOLOGY help file is shown in Figure 2.

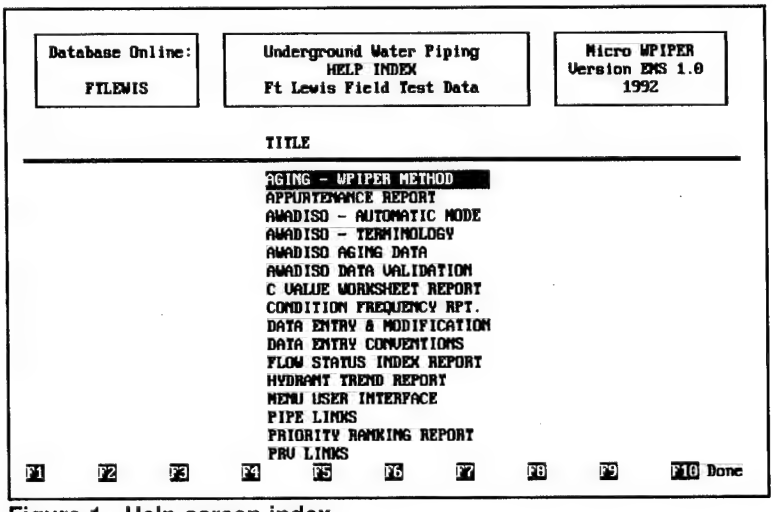


Figure 1. Help screen index.

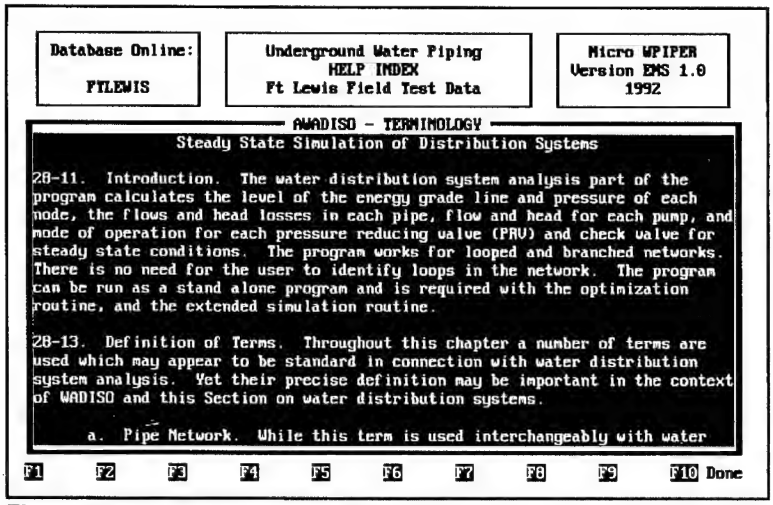


Figure 2. Sample help screen.

To exit from any of these screens, press **[F10]**. To return to the DATA ENTRY AND MODIFICATIONS menu, press **[F10]** from the aging data entry screen.

4.4 Use of WPIPER Databases With Other Software

The WPIPER databases are in dBase III and IV format. This means that they can be copied for use with other software. There are two things that you must change to be able to access the databases from other programs such as dBase or Paradox. First, WPIPER databases have a ".DWP" file extension, unlike a typical dBase file, which has a ".DBF" extension. Second, all databases created by WPIPER are "read only" to prevent accidental erasure or contamination. To access the WPIPER databases using other software, make a copy of the database as described above. Remove the "read only" protection from the file using the DOS "ATTRIB" command or your file management program. Rename the database files to have a ".DBF" extension.

4.5 Installing WPIPER 1.0

The DOS CONFIG.SYS files should include the following command lines. Check your CONFIG.SYS file and modify it if necessary.

DEVICE = ANSI.SYS
BUFFERS = 16
FILES = 49

If you have DOS 3.3, setting FILES to an even number uses large amounts of RAM. Always set FILES to an odd number to overcome this limitation. It is recommended that DOS 5.0 or higher be installed and optimized to obtain available memory of not less than 600 kilobytes (KB). To display the available memory, type **CHKDSK** or **MEM** (DOS 5.0) at the DOS prompt.

If you do not have a CONFIG.SYS file, use a text editor to create one containing at least the above three lines. The CONFIG.SYS files must be in the ROOT directory. The ANSI.SYS file does not have to reside in the ROOT directory. If it does not, you must specify its path. If you do not know how to do this, consult your computer operations manual or your computer systems operator.

When you receive the WPIPER program, it will be stored on diskettes. It is recommended that you make a backup copy of the software before you install it on the hard drive of your computer. These diskettes are not copy-protected. If you wish to make a backup copy of the software, you must use the DOS DISKCOPY command and blank diskettes of the same type. Consult your DOS manual for details on using the DISKCOPY command.

To begin the installation process, insert disk #1 into drive A and type:

A:> SETUP

The program will ask you for the name of the directory on the hard drive in which you wish to install the program (Figure 3). You will probably want to install the program to the directory C:\WPIPER. The program files will be copied into the directory that you specify. You will be prompted to insert disks in sequence. If the directory does not

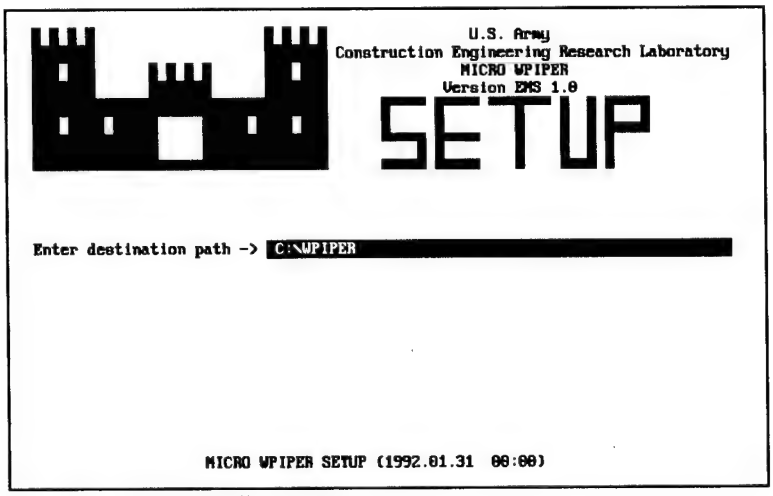


Figure 3. The SETUP program.

already exist, SETUP will prompt for confirmation before creating it. The following files will be installed:

Program files:

WPIPER.EXE
AWADISO.EXE
WPIPERDB.EXE.

System Databases:

GSI.DWP	COATING.DWP	PRESZONE.DWP,
DATABAS.DWP	CONSTRBY.DWP	QUERY.DWP
DATABAS.NWP	COVER.DWP,	RMETHOD.DWP
DATADIR.NWP	JOINT.DWP	SOIL.DWP
APPTYPE.DWP	LINING.DWP	TYPEB.DWP
BROWSE.DWP	MATERIAL.DWP	WATER.DWP.
CAUSEB.DWP	METYPE.DWP	

Online Help File:

WP *.HLP

A successfully completed setup is shown in Figure 4.

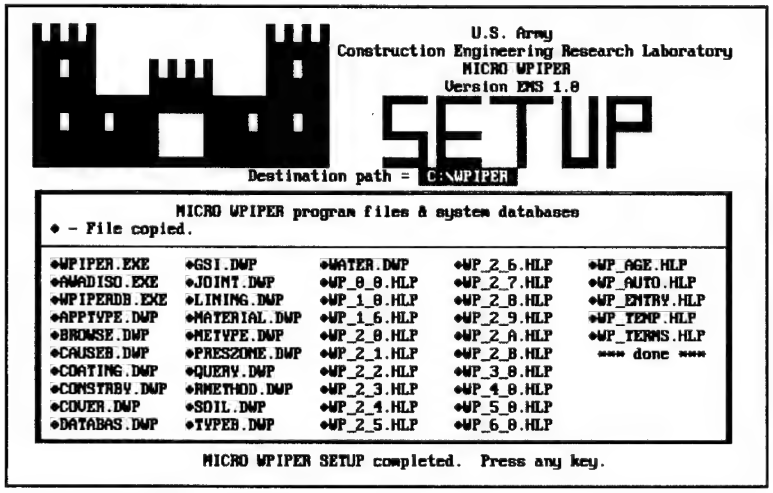


Figure 4. SETUP completed.

4.6 Starting the Program

Now that the files have been stored on the fixed disk, you may run the program. The following steps will start the WPIPER program:

1. Change to the WPIPER directory by typing:

   CD \WPIPER at the C:\> prompt.

2. Type **WPIPER** at the C:\WPIPER> prompt.

When the program starts, the screen shown in Figure 5 appears. Press any key to move to the disclaimer screen (Figure 6). It may take a few seconds for the next screen to appear. Press any key to pass this screen. The next screen, a Corps of Engineers logo screen (Figure 7), only appears if initialization is not yet complete. It may take as long as 90 seconds to initialize the program.

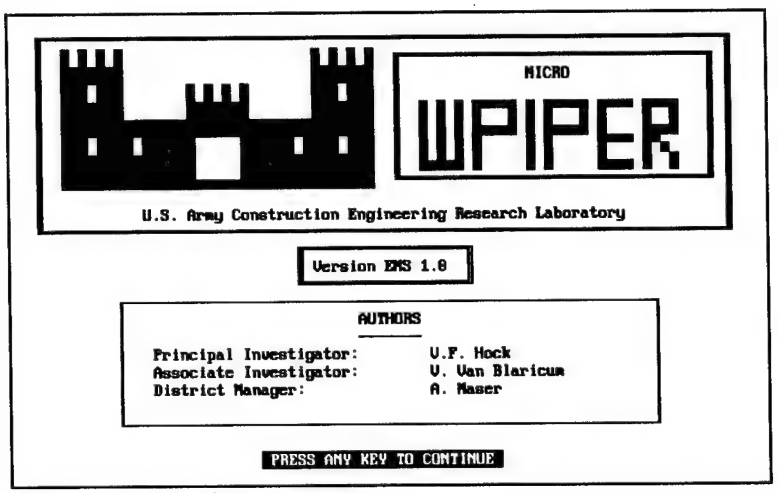


Figure 5. Initial sign-on screen.

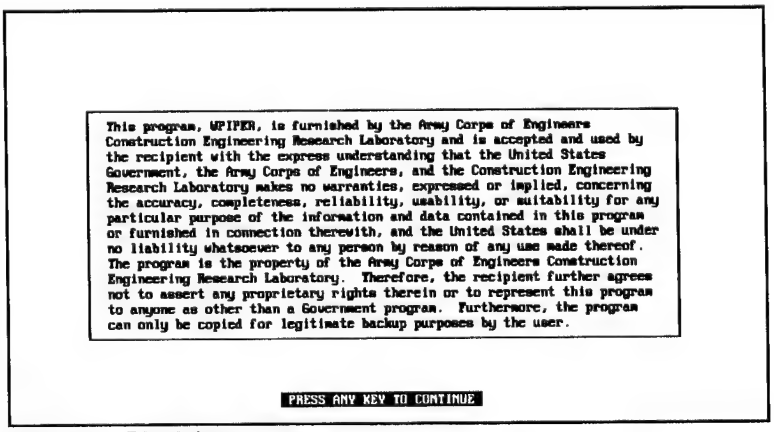


Figure 6. Disclaimer screen.

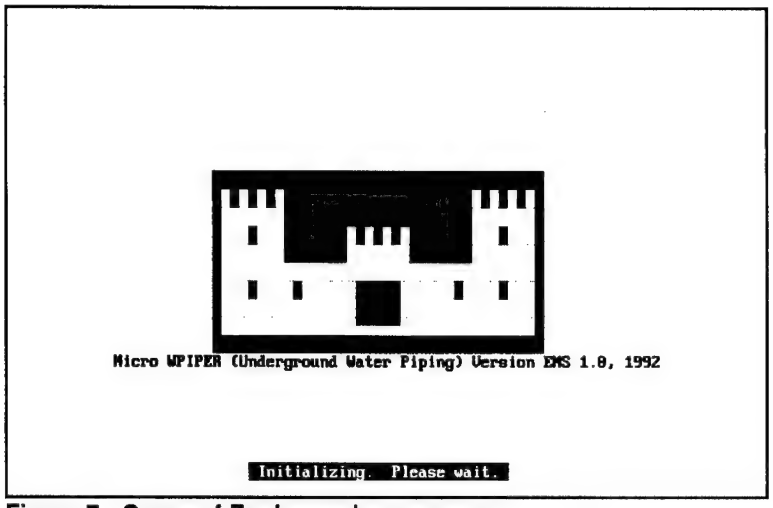


Figure 7. Corps of Engineers logo screen.

If the program does not start, verify that all procedures above were performed.

4.7 Error Messages During Start-Up

WPIPER can detect a variety of possible errors during start-up. The error that has occurred will be named in the box located in the top center of the screen, under the words "Underground Water Piping." The following paragraphs list the error messages that can appear, what they mean, and what to do about them.

4.7.1 *Insufficient Memory*

The program checks available memory to determine if there is enough to run the program's memory-intensive operations. If WPIPER reports a memory problem, exit to DOS when you are prompted. You must then increase the amount of memory available to WPIPER. This might be done by disabling any "terminate and stay resident" (TSR) programs that are running, or by using a memory manager (such as QEMM386) to optimize your computer's use of memory. If you do not know how to do this, consult your software documentation or your system administrator for help.

4.7.2 *WARNING–FREE DISK SPACE < 1MB*

The program checks the amount of storage space remaining on the hard drive. If there is less than 1 megabyte (MB) of space left, a warning message is displayed. To ensure good performance of the program, either increase the available space on the hard drive by deleting files that you no longer need, or install the program on a computer with more disk capacity.

4.7.3 *Missing Selected Database(s)*

The program also checks the databases that were in use when the program was last terminated (called the "current set" in this discussion). If this is the first time you have used the program, this procedure will be skipped. If any of the databases are missing, a message advises you of this and allows you to exit to DOS (Figure 8). You should then attempt to locate the missing file(s). Unless all databases of the current set exist, WPIPER will unselect the set. If any index files are missing from the current set, you will be informed and may answer **[Y]** to have the system create them. The program will not access a database without the associated index file.

4.7.4 *Missing Password(s)*

If any of the passwords have not been set, a screen gives a warning (Figure 9). This will happen the first time you use the program. See Section 9.1, "General System Information" in Chapter 9, "System Utility" for information on setting passwords (Section 9.1.3).

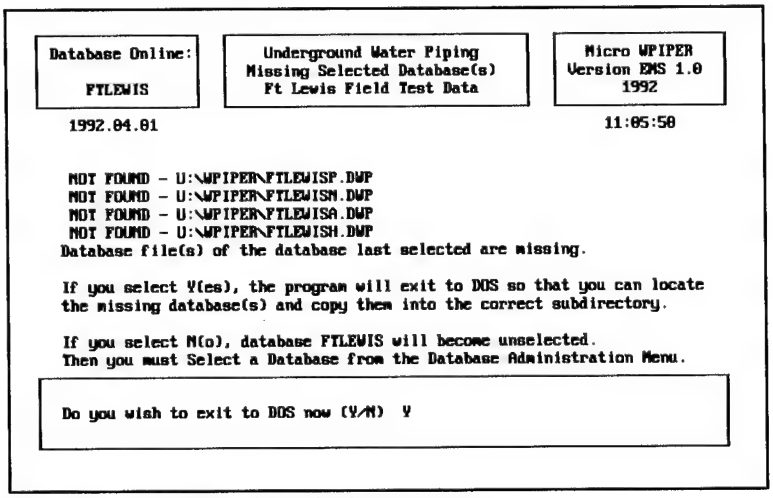


Figure 8. Database files missing screen.

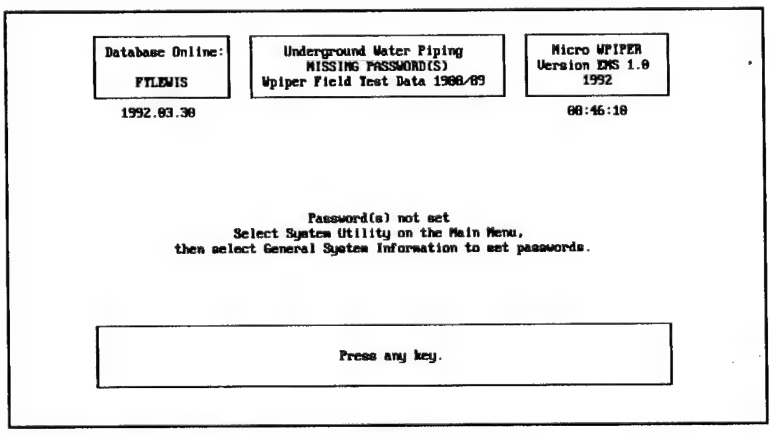


Figure 9. Passwords not set screen.

4.8 Initial Program Configuration

WPIPER is initially set up to a standard configuration that allows the program to be used immediately. Reports will be printed assuming a standard IBM GRAPHICS type or HP Laser Jet type printer. The monitor type is set to monochrome. If you have a color monitor, you may set the program to operate in color from the GENERAL SYSTEM INFORMATION item of the SYSTEM UTILITY option of the MAIN MENU. See the chapter on SYSTEM UTILITY for instructions.

4.9 Menu User Interface

The MAIN MENU (Figure 10) will appear after the start-up procedure is complete. All program options may be accessed through the menu system. The chapters that follow discuss the MAIN MENU options in detail. You may select a menu item by either of two methods.

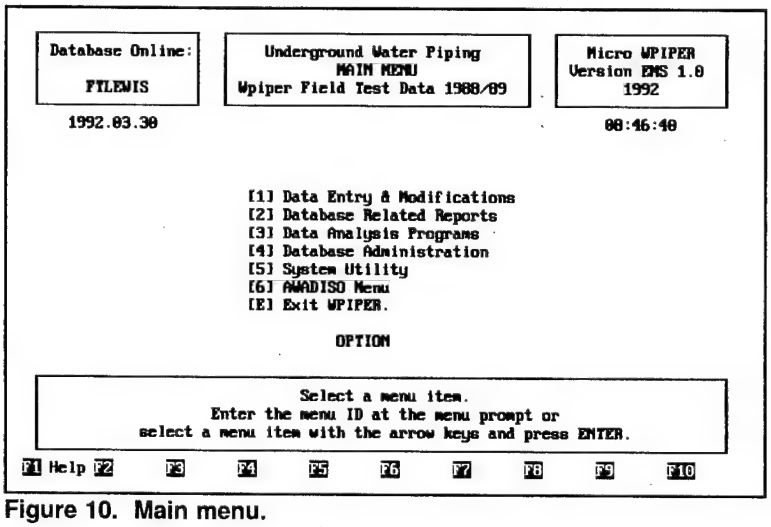


Figure 10. Main menu.

The first method is to press the **number** of the menu item that you wish to select. There is no need to press **[ENTER]** after the number.

The other method is to use the highlighted selection bar to select items. The selection bar is activated by pressing any of the **cursor keys** or **space bar**. Move the bar to the menu item that you wish to select and press **[ENTER]**. The **space bar** will move the selection bar down.

If you attempt to access main menu items **[1]** or **[2]** before a database has been selected for use, an error message will be displayed. You must first select a database

to use by following the instructions in Section 8.4, "Select A Database" in Chapter 8, "Database Administration." If no databases exist, see "Create A Database" in Chapter 8.

4.10 Quick Start Instructions

If you are an experienced computer user, you may wish to get started right away without reading this entire manual. The program is menu-driven and has extensive on-line help, so it is quite easy to use. These instructions assume that you have already collected and organized the data to be input into the program as discussed in the previous chapter.

1. At the MAIN MENU, select **[4]**, DATABASE ADMINISTRATION, and create the new database for the water distribution system that you wish to analyze. After you have created the database, choose it by using option **[3]**, SELECT A DATABASE. Its name will be displayed in the box in the upper left corner of the screen. Exit back to the MAIN MENU.

2. At the MAIN MENU, select **[1]**, DATA ENTRY & MODIFICATIONS. At the DATA ENTRY & MODIFICATIONS MENU, select **[3]**, UPDATE WATER QUALITY DATA. To enter pipe data, a water quality record for the system must first be present in the Water Quality database. Exit back to the DATA ENTRY & MODIFICATIONS MENU.

3. At the DATA ENTRY & MODIFICATIONS MENU, select **[1]**, UPDATE LINK DATA. Follow the prompts and enter all of the LINKS (pipes). You should already have an annotated map with the LINKS and NODES designated to enter into the program. When you are finished, exit to the DATA ENTRY & MODIFICATIONS MENU.

4. At the DATA ENTRY & MODIFICATIONS MENU, select **[2]**, UPDATE NODE DATA. Follow the prompts and enter all of the NODES. Remember to enter the input and output flows where applicable.

5. At the DATA ENTRY & MODIFICATIONS MENU, select **[6]**, UPDATE PIPE AGING DATA. At the prompts, enter the present date and the future date into the proper fields. This is needed before running the AWADISO Data Validation Report. For an analysis to be conducted in 1992, the present data field should be set to 1992 and the future data could be set to 2000. This would allow the pipe to be aged to create a network balance with "C" values aged to the year 2000 to show how the system would react in the year 2000. Based on the forecast performance, you can

then determine areas of concern that could need relining, cleaning, or replacing. This is discussed in more detail in section 5.6 of this manual. In addition, significant on-line help is available to assist in setting up aging data. Exit back to the MAIN MENU.

6. At the MAIN MENU, select **[2]**, DATABASE RELATED REPORTS. At the DATABASE RELATED REPORTS MENU, select **[3]**, AWADISO DATA VALIDATION REPORT. Prepare a copy of the report. This report fully checks the data entered into the database and lists any errors that need to be corrected before a hydraulic analysis can be performed. Return to the DATA ENTRY & MODIFICATIONS MENU to correct the reported errors. Run the Data Validation Report again. When the Data Validation Report indicates that no errors are present in the database, exit to the MAIN MENU.

7. At the MAIN MENU, select **[6]**, AWADISO MENU. Then select either **[3] or [4]**, Run AWADISO Automatically with or without aging. The passing of the data to AWADISO is automatic and requires no further input. Results can either be sent to a printer or displayed on the screen.

8. If you wish to generate other reports using the currently specified piping network and operating scenario, exit to the MAIN MENU. Select **[2]**, DATABASE RELATED REPORTS, or **[3]**, DATA ANALYSIS PROGRAMS. Generate the reports by selecting them from the menu.

9. If you wish to analyze other network operation scenarios, enter other demands and set other fixed grade nodes using DATA ENTRY & MODIFICATIONS. For example, you may wish to analyze fire flows at various hydrants, or you may wish to analyze the effect of proposed new construction.

5 Main Menu Option 1: Data Entry and Modifications

As explained previously, there are several databases that contain data about an underground water piping system. This chapter explains the procedures for entering data into, modifying data in, and deleting data from these databases.

Data Entry and Modification is accessed by selecting option [1] from the MAIN MENU. The DATA ENTRY & MODIFICATIONS MENU will appear (Figure 11). There are six databases that can be accessed from this menu. These are the databases containing data about the underground water piping system.

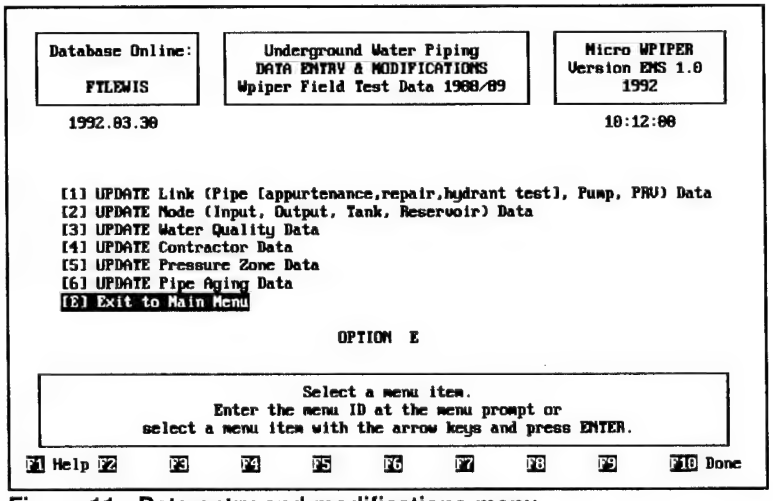


Figure 11. Data entry and modifications menu.

5.1 Data Entry and Modifications Menu Option 1: Update Link Data

This item is used to enter data about the links comprising the water distribution system. This includes information about pipes, pumps, appurtenances, PRVs, repairs, and hydrant test data. This selection provides the ability to add records, modify (edit) records, and delete records.

All actions are password protected, so you must know the correct passwords to perform these functions. You will be prompted for a password after you select the UPDATE LINK

DATA option (Figure 12). Entry of the "Add/Edit" password will allow you to add or edit data only. Entry of the "Delete" password will allow you to add, modify, or delete data. Entry of an erroneous password will return you to the DATA ENTRY & MODIFICATIONS MENU.

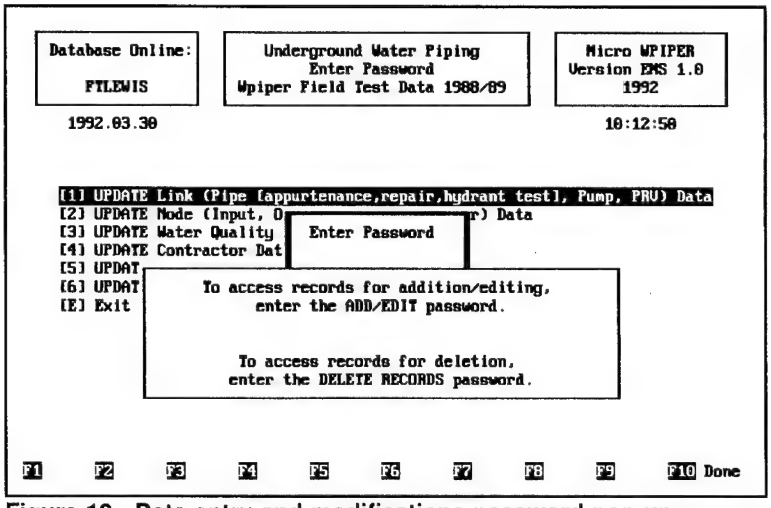


Figure 12. Data entry and modifications password pop-up.

5.1.1 *Selecting a LINK To Work With*

After you enter a password, you will be asked to enter the LINK Number with which you want to work. If the LINK already exists in the database, you may either type the number directly into the field, or you may select it from the pop-up list. To display the pop-up list, press **[F9]** (Figure 13). To select from the pop-up list, press **[F9]** again. Move the selection bar so that it highlights the LINK you want to work with. Press **[ENTER]** to select it. If you do not wish to select from the pop-up list, press **[F10]** to return to the data entry field. If you wish to display the list of editing keys and their functions, press **[F2]** (Figure 14).

If you have not previously entered data for this LINK, type its number. You will be asked if you wish to create the record. If the record does not exist, a pop-up window appears indicating that the record does not exist and lists options in a menu (Figure 15).

This menu has five options to allow you to select the type of LINK you wish to create. To create a new pipe record using the LINK Number entered, select option 1, "Create a new pipe." To create a new pump record with 3 data points from the pump's characteristic curve, select option 2, "Create a new pump - 3 points on a curve."

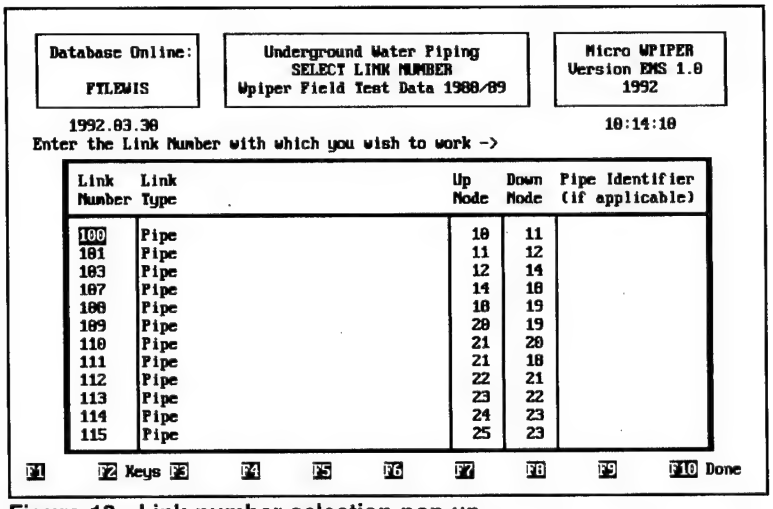


Figure 13. Link number selection pop-up.

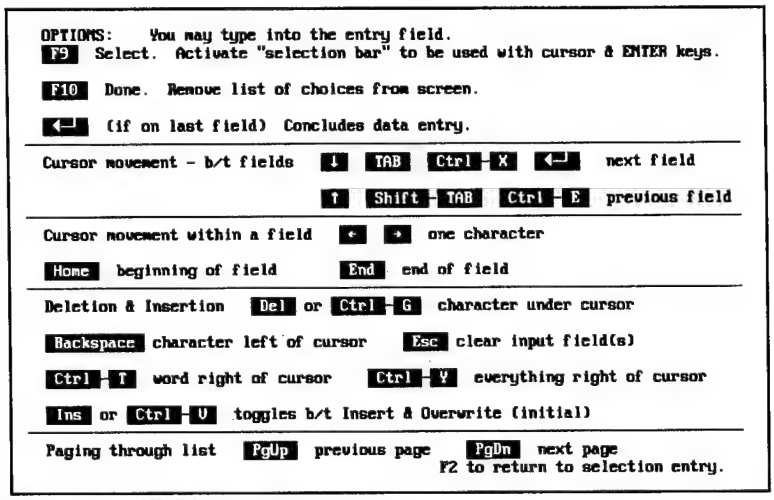


Figure 14. [F2] key usage screen.

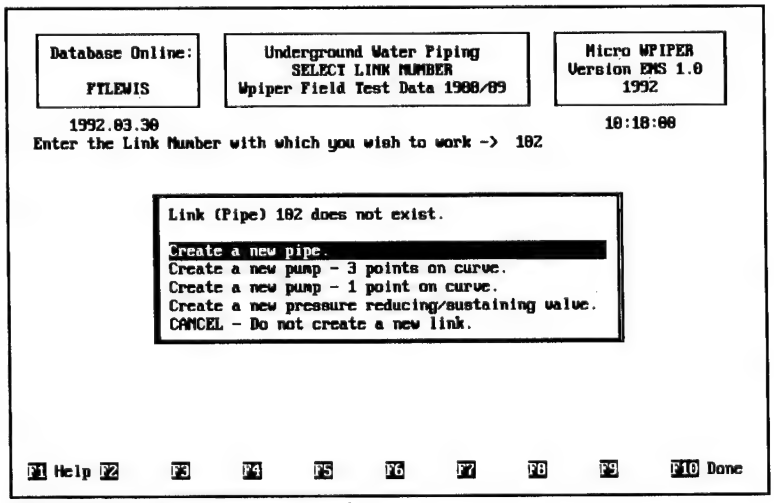


Figure 15. Creating a new link.

To create a new pump record with one point on the pump's characteristic curve, select option 3, "Create a new pump - 1 point on a curve." To create a new pressure reducing valve (PRV) record, select option 4, "Create a new pressure reducing/sustaining valve." To exit from the menu without creating a new link, select option 5, "CANCEL." If you need help with the items on this menu, press **[F1]**.

To exit from the link selection screen without selecting a link, leave the entry field blank and press **[F10]**.

After you have selected an existing link or created a new link, the Update Link Data Menu (Figure 16) will appear. Note that the quantity of APPURTENANCES, HYDRANT TESTS, and REPAIRS attached to this LINK Number is listed on the right side of this menu.

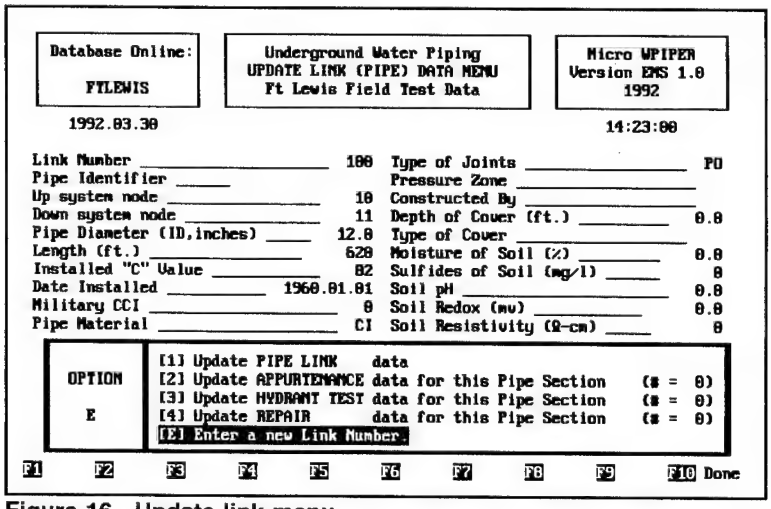


Figure 16. Update link menu.

5.1.2 *Update Link Data Menu Option 1: Update Pipe Link Data*

This option allows you to enter or edit data about the pipe link that you have selected. If you have entered the DELETE password, this option also allows you to delete the link from the database. Assuming that you entered the DELETE password, selecting this option invokes a screen that asks if you want to Modify, Purge, or Quit (Figure 17). Pressing **[M]** allows you to go to the data entry screen for the pipe link that you have selected, where you may enter new data or modify existing data. Pressing **[P]** will invoke a screen that allows you to purge (delete) the record. Pressing **[Q]** will return you to the UPDATE PIPE DATA MENU.

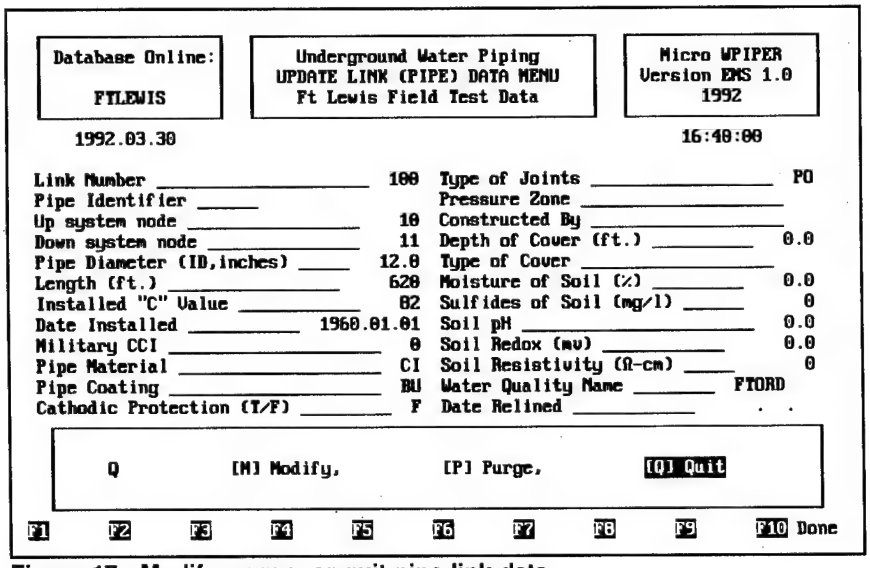


Figure 17. Modify, purge, or quit pipe link data.

If you pressed **[P]**, you will be asked if you wish to purge (delete) the selected record. Use this option with care. This option is used to delete an entire LINK and all of the APPURTENANCES, HYDRANT TESTS, and REPAIRS associated with it. You will be asked twice to confirm that you wish to delete the pipe section and all associated data. Answering **[Y]** both times will cause these records to be deleted. The procedure for deleting individual appurtenances is described in section 5.1.3.

If you pressed **[M]**, you will be presented with the pipe link data entry screen (Figure 18). If this is an existing record, the data that is currently in the database will appear on the screen. If this is a new record, some fields may be filled in with data from a previously edited record. Enter or edit the data on this screen as you wish. Press **[F2]** to see a list of the editing keys. There are some fields that must be filled in before you can exit this screen. This maintains the integrity of the database and ensures that

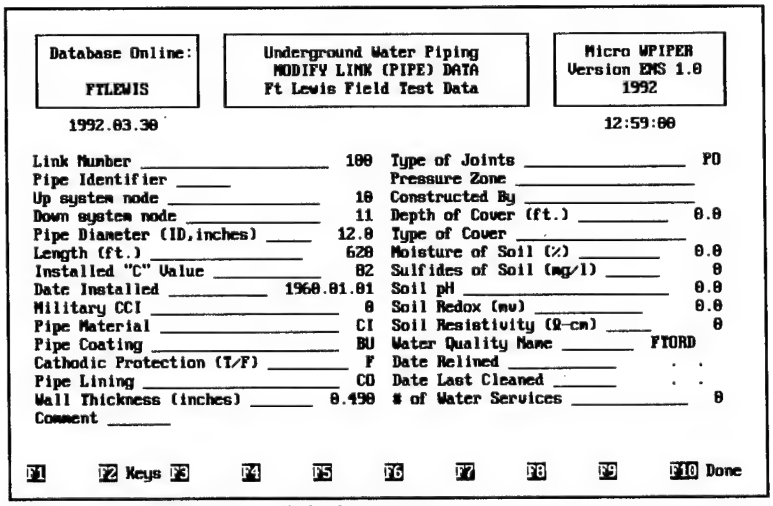


Figure 18. Modify pipe link data screen.

database-wide computations can proceed without computational errors (such as division by zero) that are caused by missing data. A small pop-up dialog box stating **REQUIRED** will be displayed adjacent to these fields.

Lists of possible values are available for some of the fields. If a list is available for a given field, the function key menu at the bottom of the screen will display "**[F9]** List." To display the list, press **[F9]**. As usual, to select from the list, press **[F9]** again and use the highlighted selection bar to make your choice.

When you are finished editing data on this screen, press **[ENTER]** on the last field or press **[F10]** on any field. You will be asked if you wish to Accept, Modify, or Quit (Figure 19). Press **[A]** to accept the record and store it in the database. Each field in the record will be validated; and you will be returned to the UPDATE LINK (PIPE) DATA MENU. If a field is invalid, a pop-up window will state the problem, then position the cursor at the invalid field. If the LINK NUMBER has been altered on an existing record, you must confirm the change with a **Y/N** at the prompt. Press **[M]** to go back and modify data. Press **[Q]** to throw away the changes that you have just made, and return to the UPDATE LINK (PIPE) DATA MENU. The data that you have just entered will not be stored in the database. If this is a newly created record, it will be cancelled and the program will return to the SELECT LINK NUMBER prompt.

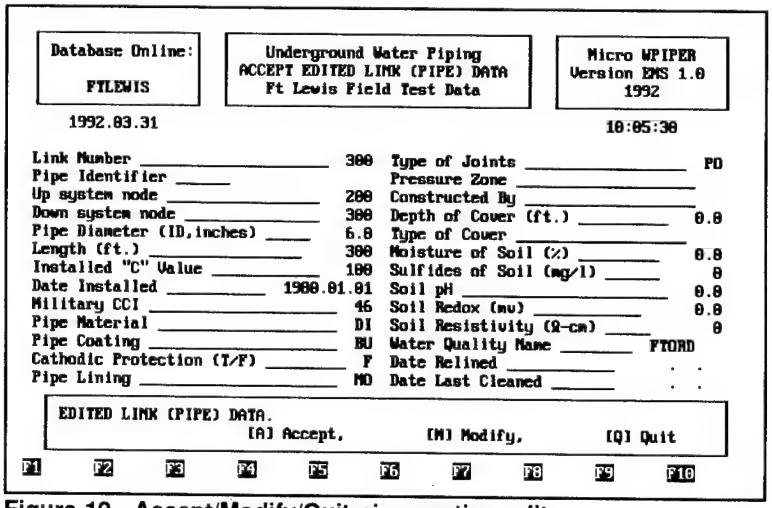


Figure 19. Accept/Modify/Quit pipe section edit.

5.1.3 *Update Link Data Menu Option 2: Update APPURTENANCE data for this Link Number*

This option is used to enter data about the appurtenances that are associated with the selected LINK number. When this option is selected, you will be presented with the APPURTENANCE KEY screen. You may type in an APPURTENANCE KEY and

press **[RETURN]**. If you wish to see a list of existing appurtenances, press **[F9]** to display the Appurtenance Key pop-up (Figure 20). Pressing **[F9]** again will actuate the selection bar selector in the pop-up. Move to the Appurtenance Key desired, using the cursor keys, and press **[ENTER]** to select the record. If you type in a key that does not exist in the database, you will be asked to select the type of appurtenance you wish to create. If the Key exists, the record is displayed and a menu asking whether to Modify, Purge, or Quit this record is shown at the bottom of the screen.

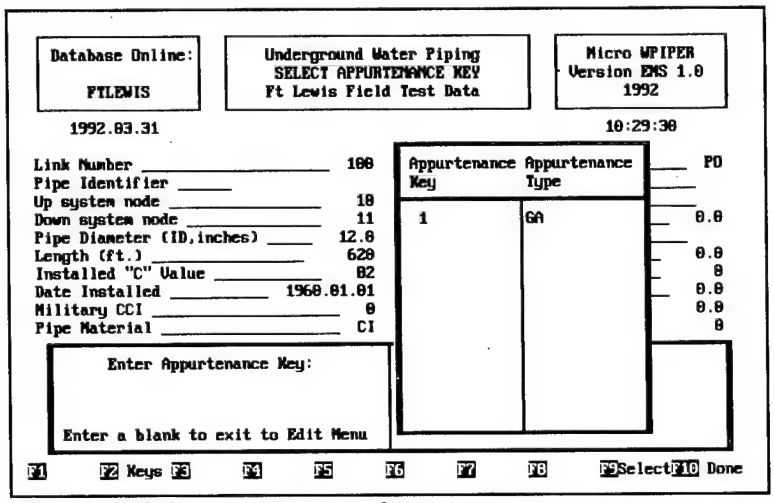


Figure 20. Select appurtenance key screen.

Figure 21 shows the data entry screen for a Gate Valve Appurtenance. There are many appurtenances, and they are all entered or edited the same way. Press **[F2]** to see a list of the editing keys. When you are finished entering data for this appurtenance, press **[F10]**. The Accept, Modify, Quit screen will appear. To accept the entries displayed in the record fields, press **[A].** To return to the data fields for more editing, press **[M].** To quit and abandon the changes you have just made, press **[Q]**. **Options [A]** and **[Q]** (except on a new record) will return you to the UPDATE LINK (PIPE) DATA MENU.

5.1.4 *Update Link Data Menu Option 3: Update HYDRANT TEST Data for This LINK Number.*

This option is used to enter data about periodically-conducted hydrant flow tests at selected appurtenances (hydrants). APPURTENANCE KEY (Hydrant) screen will appear. You may type in an APPURTENANCE KEY (Hydrant) and press **[RETURN]**. If you wish to see a list of existing hydrants, press **[F9]** to display the Hydrant Key pop-up. Pressing **[F9]** again will actuate the selection bar selector in the pop-up. Move to the Hydrant Key desired, using the cursor keys, and press **[ENTER]** to select the hydrant to add test results. One hydrant may have many hydrant tests.

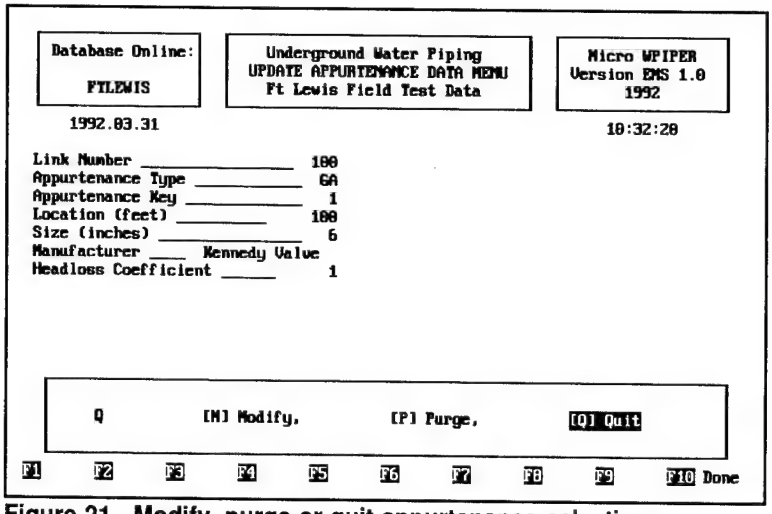


Figure 21. Modify, purge or quit appurtenance selection.

If you type a Hydrant Test Number that does not exist, you will be prompted to create the record (Figure 22). Press **[Y]** to create the record and invoke the data entry screen (Figure 23). When you are finshed entering data for this record, press **[F10]**. You will be presented with a menu asking whether to Accept, Modify, Purge, or Quit this record, depending on whether the record was a new record or is being updated. These functions work as described previously. If you have previously entered the "Delete" password, you may purge (delete) the record at this point. Use this option with care.

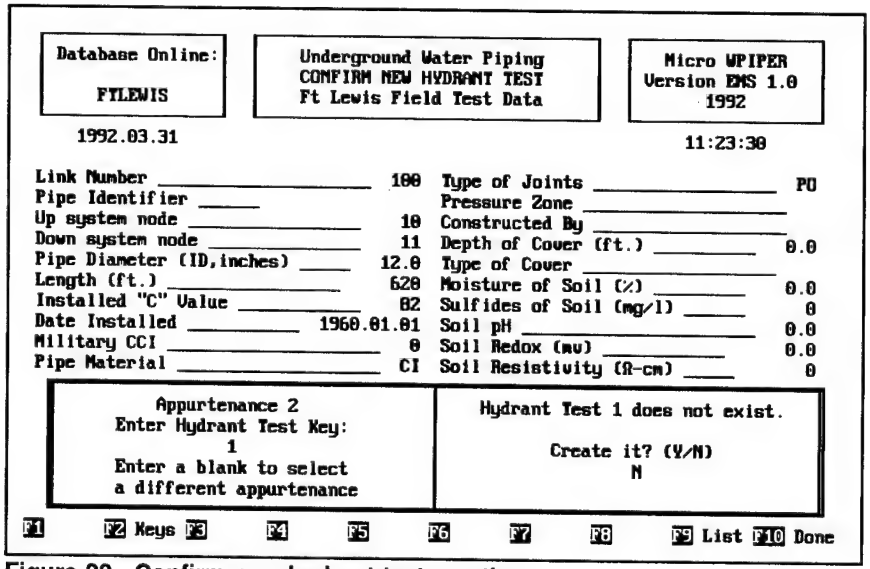


Figure 22. Confirm new hydrant test creation.

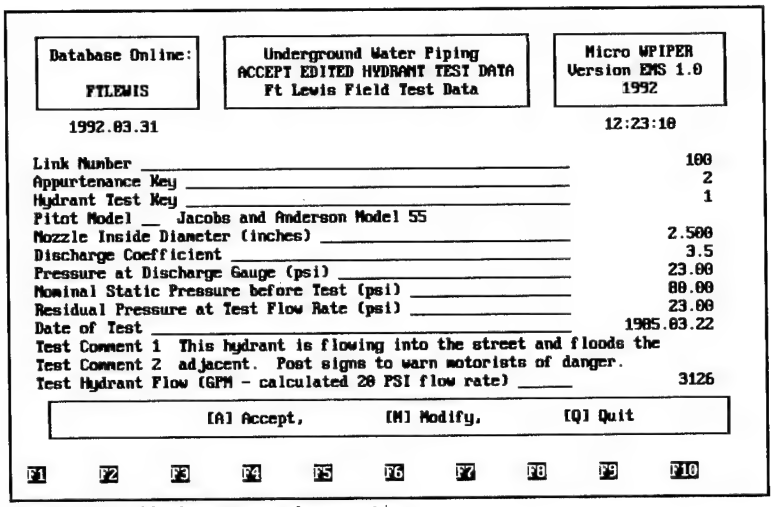


Figure 23. Hydrant test data entry.

5.1.5 *Update Link Data Menu Option 4: Update REPAIR Data for this pipe section*

This option allows you to enter repair data for the pipe section or LINK that you have selected. Select existing Repair Keys or create a new one using the same procedures as described above for APPURTENANCES and HYDRANT TESTS. After you have selected or created a Repair Key, you will be presented with the data entry screen shown in Figure 24. When you are finished entering data, press **[F10]** and respond to the prompts as described previously.

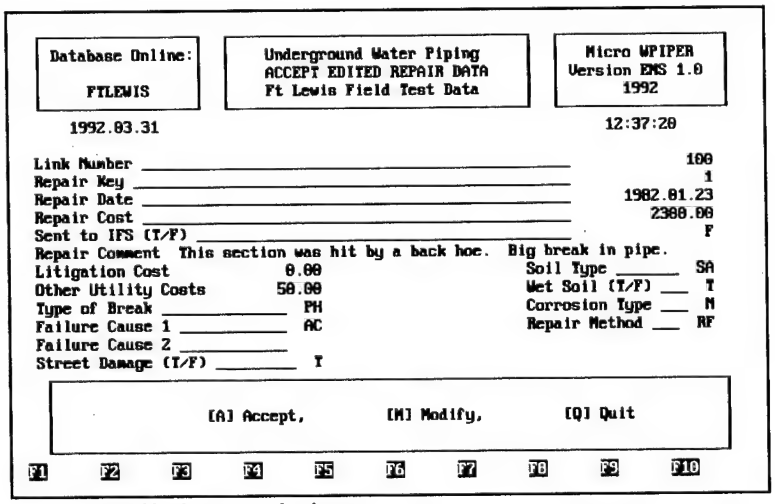


Figure 24. Update repair data.

5.1.6 *Update Link Data Menu Option E: ENTER new LINK Number*

This option allows you to select a different link to work with. Press **[E]** to return to the blank LINK entry field. If you wish to work with another link, select it as described

previously. If you do not wish to work with another link, pressing ENTER at the blank link field or press **[F10]** to return to the DATA ENTRY & MODIFICATIONS MENU.

When you finish updating the records, the program permanently removes the records that you have chosen to delete from the database and updates the index files. You will be informed of the update process with a progress screen.

5.2 Data Entry and Modifications Menu Option 2: Update Node Data

This option is used to enter NODE data into its database. As explained previously, a NODE is a location where one or more pipes join. After you select this option, you will be asked to enter the NODE Number with which you want to work. If the NODE already exists in the database, you may either type the number directly into the field, or you may select it from the pop-up list. To display the pop-up list, press **[F9]**. To select from the pop-up list, press **[F9]** again. Move the selection bar so that it highlights the NODE with which you want to work. Press **[ENTER]** to select it. If you do not wish to select from the pop-up list, press **[F10]** to return to the data entry field.

If you have not previously entered data for this NODE, type its number. You will be asked if you wish to create the record. Press Y to create it. The water quality name is the name of the source that supplies the water conveyed by the system, such as "PLANT 1" or "WELL 3." Press N to return to the previous screen without creating the record.

After you have selected a NODE to work with, you will be asked if you wish to Modify, Purge, or Quit this record. As described previously for LINK data, press **[M]** to go to the data entry screen for the node that you have selected, where you may enter new data or modify existing data. To purge (delete) the record, press **[P]**. To go back to the previous screen, press **[Q].**

If you pressed **[P]**, you will be asked if you wish to purge (delete) the selected record. Use this option with care. You will be asked to confirm that you wish to delete the node and all associated data. Answering **[Y]** will cause the record to be deleted.

If you pressed **[M]**, you will be presented with the node data entry screen (Figure 25). If this is a previously existing record, the data that is currently in the database will appear on the screen. Enter or edit the data on this screen as you wish. Press **[F2]** to see a list of the editing keys. There are some fields that *must* be filled in before you can exit this screen. These fields will be indicated by prompts. When you are finished

entering data, press **[F10]**. You will be asked if you wish to Accept, Modify, or Quit. Respond as described previously under UPDATE PIPE (LINK) DATA.

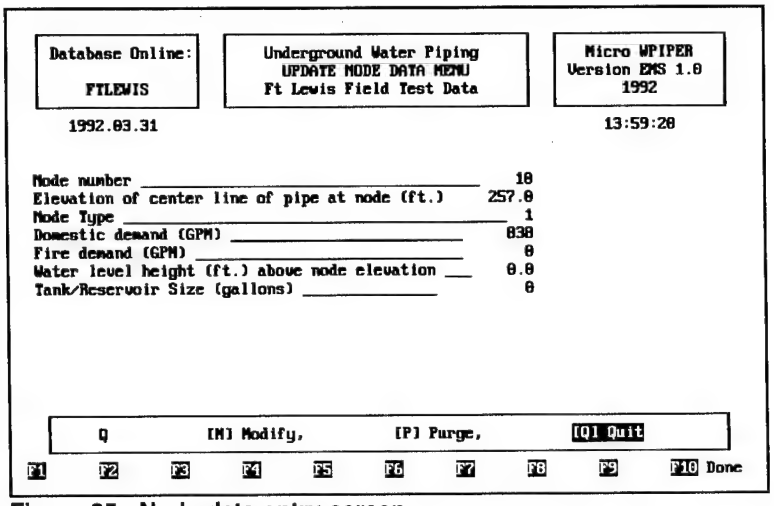


Figure 25. Node data entry screen.

The NODE Data screen will be used frequently to set up flow conditions for the various scenarios to be analyzed (such as fire flow conditions at a given node, or maximum summer demand conditions).

5.3 Data Entry and Modifications Menu Option 3: Update Water Quality Data

This option allows the input of water chemistry data. Water chemistry data is used in the pipe aging routine. After you select this option, you will be asked to enter the water quality name you want to work with. The water quality name is the name of the source that supplies the water conveyed by the system such as "PLANT_1" or "WELL_3". If the water quality record already exists in the database, you may either type the name directly into the field, or you may select it from the pop-up list. To display the pop-up list, press **[F9]**. To select from the pop-up list, press **[F9]** again. Move the selection bar so that it highlights the water quality you want to work with. Press **[ENTER]** to select it. If you do not wish to select from the pop-up list, press **[F10]** to return to the data entry field.

If you have not previously entered data for this water quality, type its name. You will be asked if you wish to create the record. Press Y to create it. Press N to return to the previous screen without creating the record.

After you have selected a water quality with which to work, you will be asked if you wish to Modify, Purge, or Quit this record. As described previously for LINK data,

pressing **[M]** allows you to go to the data entry screen for the water quality that you have selected, where you may enter new data or modify existing data. Pressing **[P]** will invoke a screen that allows you to purge (delete) the record. Pressing **[Q]** will return you to the previous screen.

If you pressed **[P]**, you will be asked if you wish to purge (delete) the selected record. Use this option with care. You will be asked to confirm that you wish to delete the water quality record. Answering **[Y]** will cause the record to be deleted.

If you pressed **[M]**, you will be presented with the water quality data entry screen. If this is a previously existing record, the data that is currently in the database will appear on the screen. Enter or edit the data on this screen as you wish. Press **[F2]** to see a list of the editing keys. There are some fields that *must* be filled in before you can exit this screen. These fields will be indicated by prompts. When you are finished entering data, press **[F10]**. You will be asked if you wish to Accept, Modify, or Quit. Respond as described previously under UPDATE PIPE (LINK) DATA.

5.4 Data Entry and Modifications Menu Option 4: Update Contractor Data

This option allows you to store information about the contractors who installed or performed work on the water distribution system. This is for recordkeeping purposes only and is not used in the hydraulic analysis or pipe aging routines. Figure 26 shows the contractor data entry screen. Use the same procedures for selecting, creating, and editing records as described previously for the other menu options.

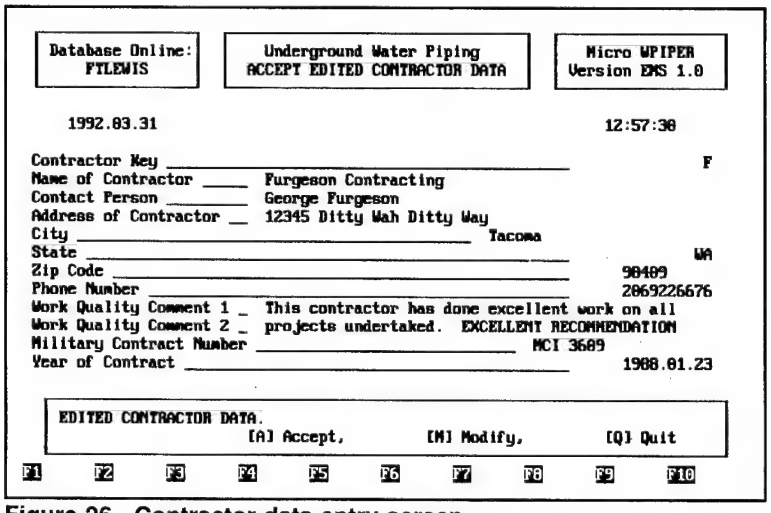


Figure 26. Contractor data entry screen.

5.5 Data Entry and Modifications Menu Option 5: Update Pressure Zone Data

This option allows you to input information on pressure zones, if your system has them. Use the same procedures for data entry as for the other menu options described previously. The pop-up dialog boxes will help you select the correct Key.

5.6 Data Entry and Modifications Menu Option 6: Pipe Aging

This option allows you to input the information that WPIPER will use to predict future flow capabilities (carrying capacity) of the water distribution system. The program will "age" the distribution system according to the information that is entered here. The methodologies used for aging, along with the meaning of the terms "Base Year" and "Future Year," are described in detail in Appendix A. This option is particularly valuable for forecasting whether or not sections of the distribution system will be able to meet fire flow demand in future years.

After you have selected this option from the menu, you will be presented with the screen shown in Figure 27. You must fill in both the BASE YEAR and FUTURE YEAR fields; otherwise, you will receive an error message when you attempt to age the system. After you have finished entering the base and future year, the Accept, Modify, or Quit menu will appear. Press **[A]** to accept the years that you have entered. Press **[M]** to change them. Press **[Q]** to quit without saving what you have done. After you have accepted the data on this screen, you will be asked if you wish to edit the aging data for the individual pipes. This allows you to specify the method that the program will use to age each individual pipe and to enter or update C-factor data. To do so, answer **[Y]**. To return to the DATA ENTRY AND MODIFICATIONS menu, press **[N]**.

If you choose to edit the individual pipe aging data, the screen shown in Figure 28 will appear. You may edit the AGING METHOD, ALPHA VALUE, LAST MEASURED C VALUE, AGE @ TEST TIME, and AVERAGE DIAMETER fields. To edit the data for a particular pipe section, position the cursor on it and press **[F5]**. There are pop-up help boxes for each of the fields. Figure 29 shows "H" being entered as the aging method for LINK 100, along with the help pop-up.

Because of the complexity of the aging system built into WPIPER and AWADISO, significant on-line help is provided to assist you in entering the aging data. To display context-sensitive help at any point on the pipe aging data entry screen, press **[F1]**. For example, pressing **[F1]** on the "Aging Method" field will bring up an explanation of the three aging methods. To display the Help Index (Figure 1), press **[F1]** again.

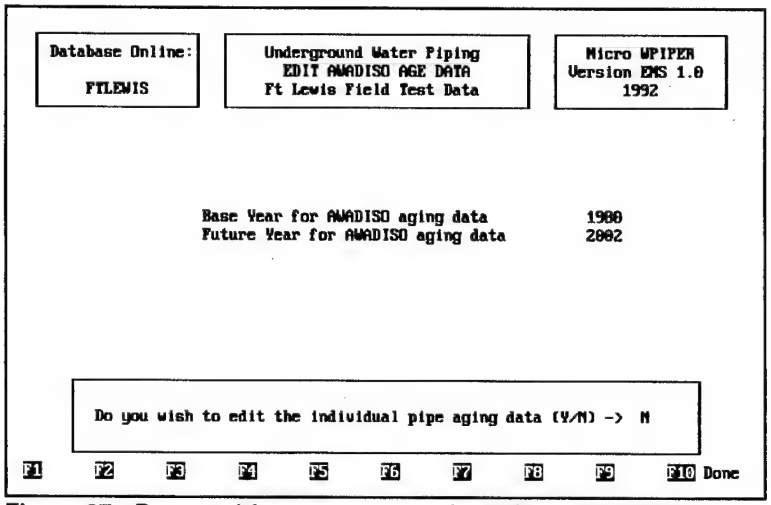


Figure 27. Base and future year entry for aging calculations.

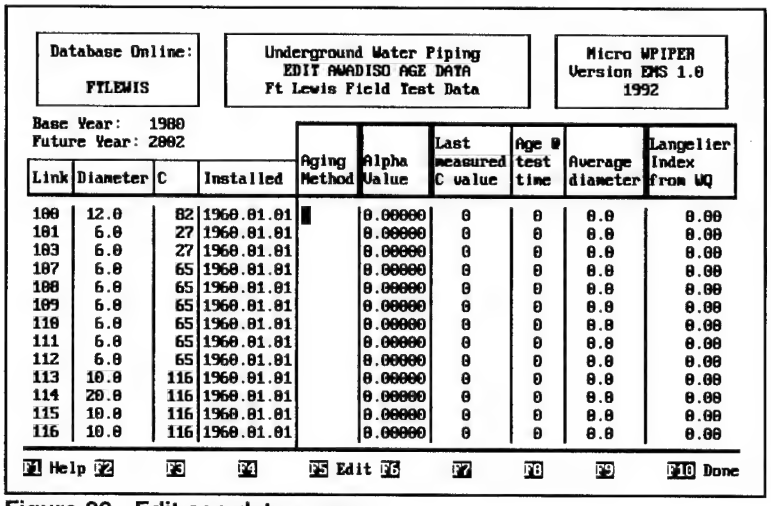


Figure 28. Edit age data screen.

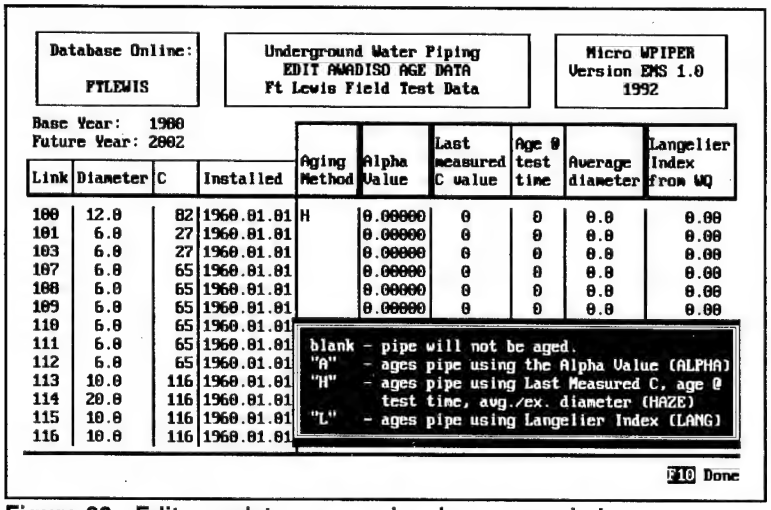


Figure 29. Edit age data screen showing pop-up help.

6 Main Menu Option 2: Database Reports

6.1 General Instructions for Generating Database Reports

This chapter will explain the generation of the reports that access information stored in the databases. WPIPER generates several preformatted reports, as well as user-specified custom reports. Database reports are accessed by pressing **[2]** from the MAIN MENU. Figure 30 shows the DATABASE RELATED REPORTS MENU.

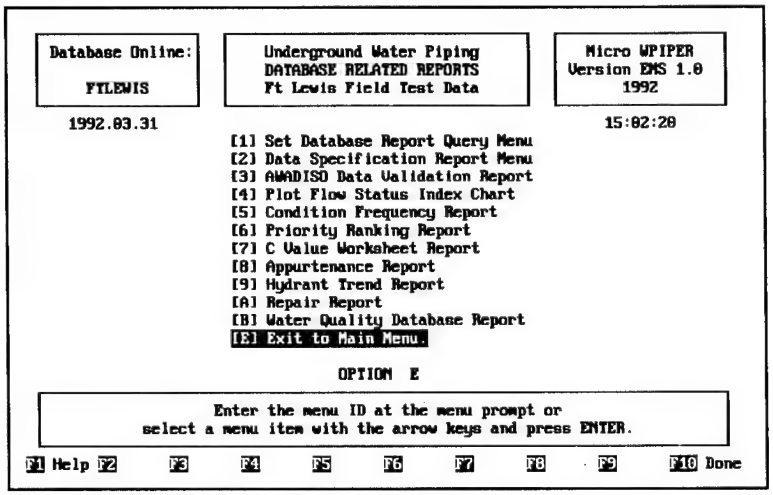


Figure 30. Database-related reports menu.

All reports are generated in the same manner. To produce a report, press the number corresponding to it or use the selection bar to choose it from the menu. You will be prompted for report-specific information. Just before the report is ready to be generated, a printer control screen will appear (Figure 31). This screen allows you to specify where you wish to print the report. To display the report on the monitor without printing it, press **[T]**.

To print the report, press **[P]**. (Instructions for setting up printers are given in the General System Information chapter). Choose the printer you wish to use by pressing the number corresponding to it (**[1]** or **[2]**), or by using the cursor keys to position the selection bar over it and pressing **[ENTER]** (Figure 32). Select the desired paper size and character pitch from the pop-up window (Figure 33) using the scrolling menu bar and press **[ENTER]**.

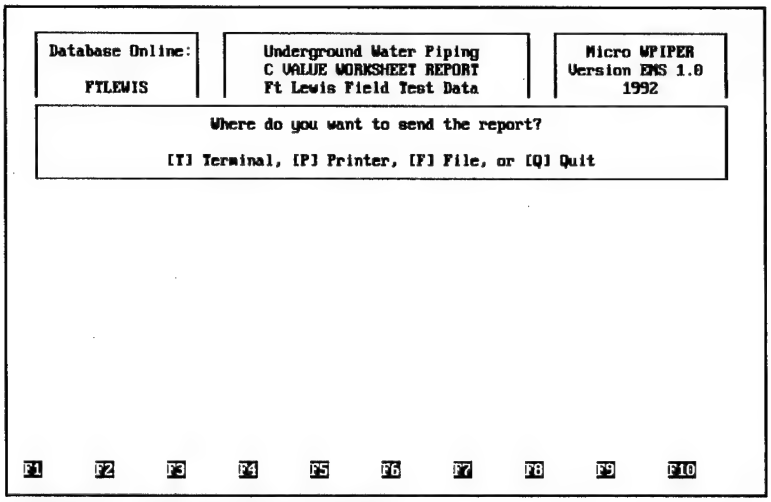


Figure 31. Printer pop-up prompt.

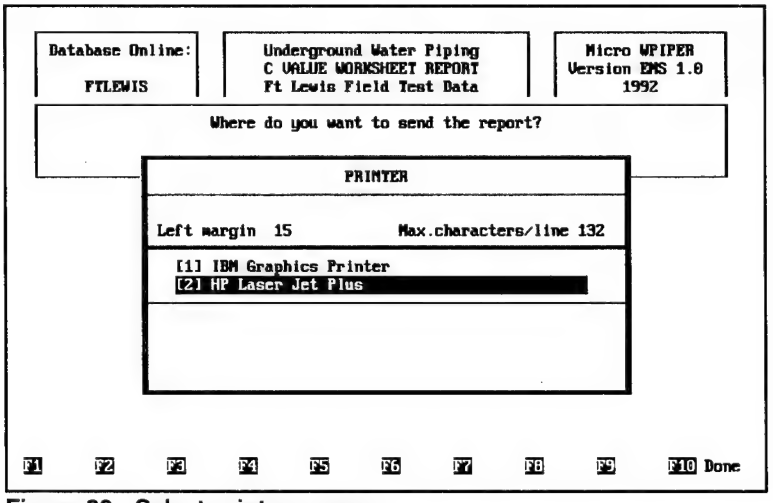


Figure 32. Select printer screen.

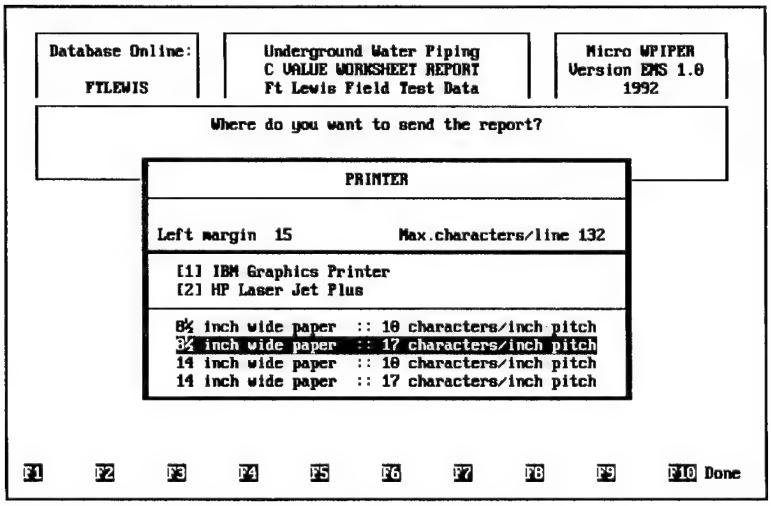


Figure 33. Select printer paper size prompt.

Finally, the Ready Printer prompt is displayed (Figure 34). Press **[F10]** or **[ESC]** to exit from this level. Press any other key to print the report.

To save the report to a file on disk without printing it, press **[F]**. You will be presented with the default file name for the report (Figure 35). If you wish to use this file name, press **[ENTER]**. If you wish to use a different file name, enter it in the field and press **[ENTER]**. The file name may be up to eight characters in length. The file extension is fixed at ".PRN". If the disk file selected for report output already exists, you will be notified and given the opportunity to overwrite it.

The options listed on the Database Reports menu will be discussed in detail in the following sections. Examples of many of the reports are shown in Appendix D.

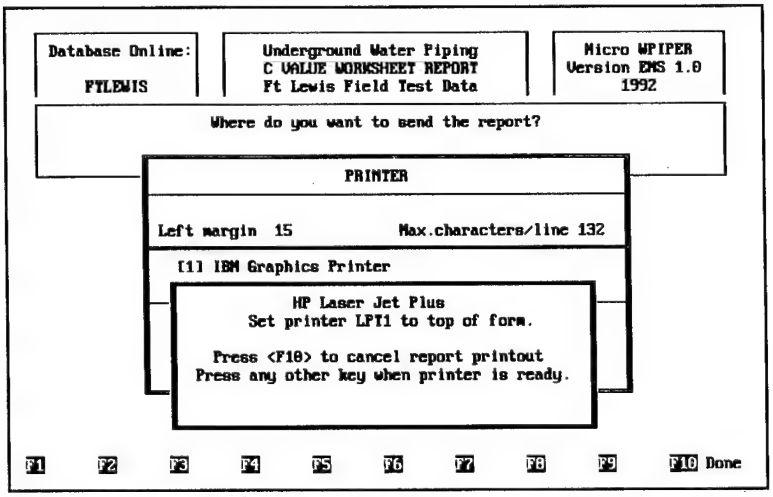


Figure 34. Ready printer prompt.

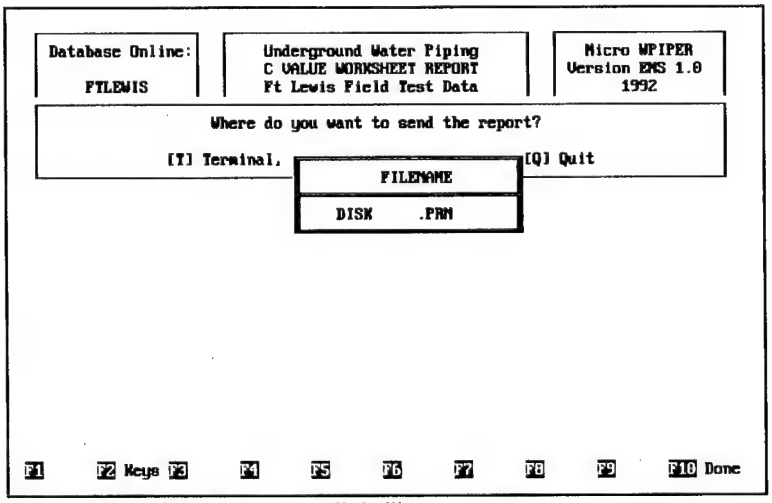


Figure 35. Print report to a disk file.

6.2 Database Related Reports Menu Option [1]: Set Database Report Query

This option allows you to customize the Data Specification Report by specifying a subset of records to include in the report (instead of generating it for the entire database). Other reports are not affected by the conditions and will be printed regardless of the conditions set. This option is especially valuable for large distribution systems with hundreds of components. For example, you might specify that a report is to be generated for all pipes made of cast iron that were installed before 1955. Only the pipe records that meet these conditions, or queries, will be included in the report.

Each query is written for a specific data field (for example, "Pipe Material" or "Date Installed"). WPIPER allows you to set up to five queries. To set queries, press **[1]** at the DATABASE RELATED REPORTS MENU. This will bring up the DATABASE REPORT QUERY menu (Figure 36). Select [1] Pipe Data, [2] Appurtenance Data, [3] Hydrant Data, or [4] Repair Data, or [E] to return to the DATABASE RELATED REPORTS menu. The following description is for pipe data, but the same general procedure is used for each of the other types of data.

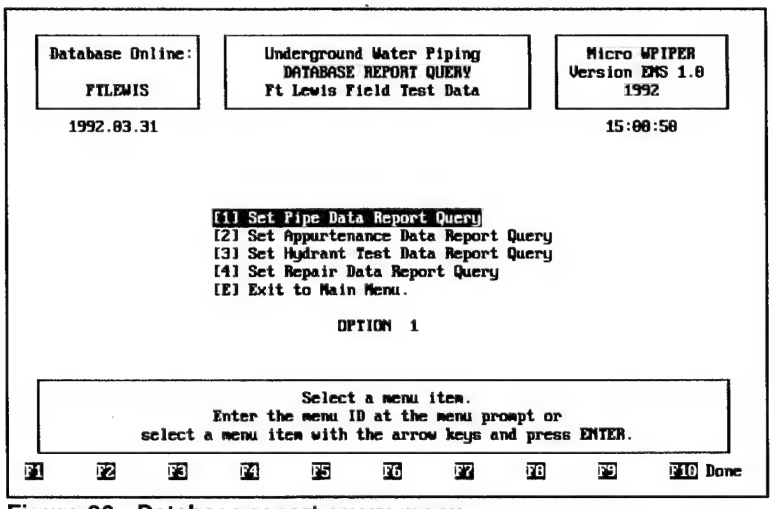


Figure 36. Database report query menu.

If you select [1] Pipe Data, you will see a box on the left side of the screen that contains a list of fields in the database, along with a highlighted selection bar. The box on the right side of the screen shows the query condition that is currently set for the highlighted field (in the left-hand box). Select the field for which you wish to set a query by using the cursor keys to position the selection bar over its name in the left-hand box. Press **[F5]** (EDIT) to select the field.

The information box on the right side of the screen will then ask you to choose what type of query you wish to set (Figure 37). The query types are exclusive and may not be combined. To select a query type, press the number that corresponds to it.

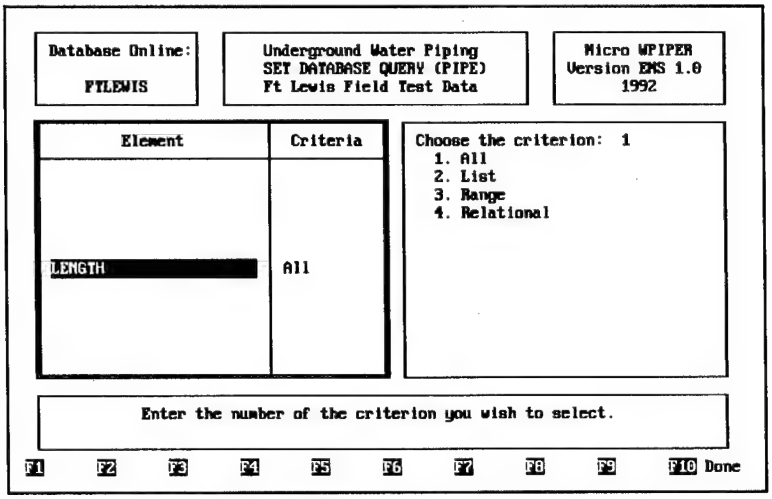


Figure 37. Select query criterion.

The query types available are:

[1] "All": This option will include all records in the database regardless of the value in the selected data field. This is typically used after you have set a query on the selected data field, generated a report using the specified subset, and wish to remove the query.

[2] "List": The List Query tests whether the value in the selected data field matches any of the values in the list that you specify. When you choose this query type, you will be prompted to enter a list of target values for the selected field. You may specify up to eight different values. For example, you might select the field "Pipe Material." You might then enter a list consisting of "CI" (cast iron) and "AC" (asbestos-cement). Only the pipes that are constructed of either cast iron or asbestos cement will be included in the report.

[3] "Relational": The Relational Query tests whether the value in the selected data field is either (1) greater than (>), (2) greater than or equal to (≥), (3) less than (<), or (4) less than or equal to (≤) a target value that you specify. When you choose this query type, you will first be asked to specify the mathematical operator (Figure 38). Next, enter the target value. The completed relational query will then be displayed in the right-hand box (Figure 39). The condition in this example will include only those pipe sections installed on 1980.01.01 or earlier.

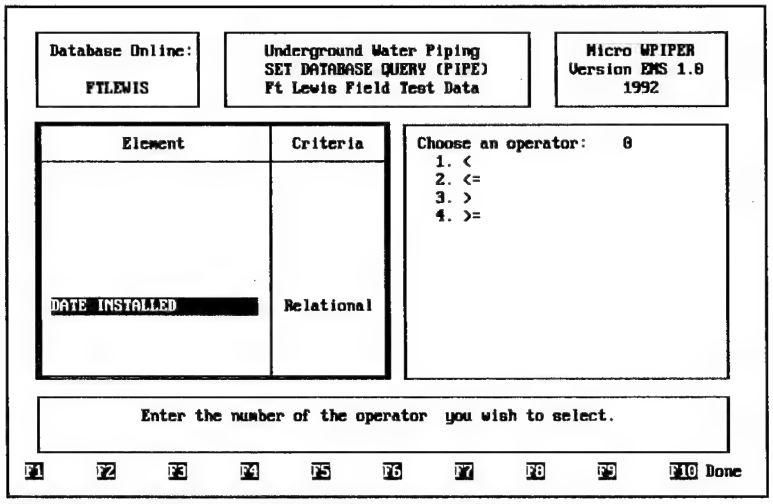


Figure 38. Selecting relational query operator.

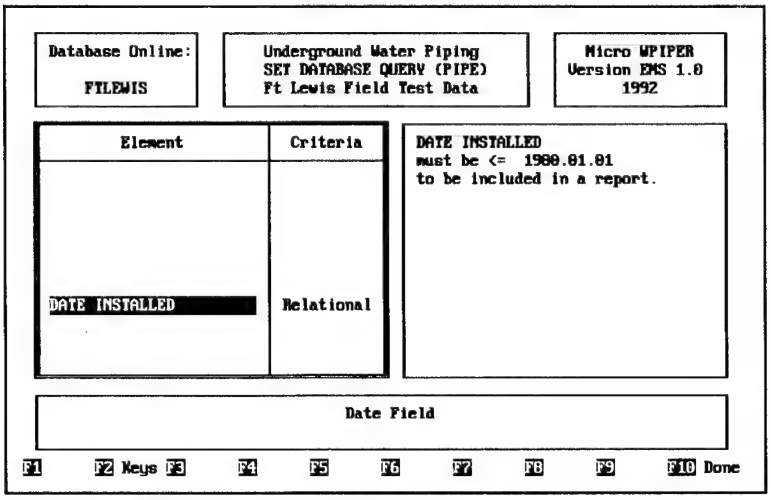


Figure 39. Relational query condition.

[4] "Range": The Range Query tests whether the value in the selected data field falls between two values that you specify. When you choose this query type, you will be asked to specify the two values. For example, in Figure 40, the record must have a date in the range of 1970.01.01 to 1980.01.01 in the DATE INSTALLED field to be included in the report. Pipe sections installed before 1970.01.01 or after 1980.01.01 will be excluded.

When you are finished entering the query, you will be asked if you wish to accept, modify, or quit. If you wish to accept the query as written, press Accept **[A]**. If you wish to edit the query, press Modify **[M]**. If you wish to exit without saving the query, select Quit **[Q]**.

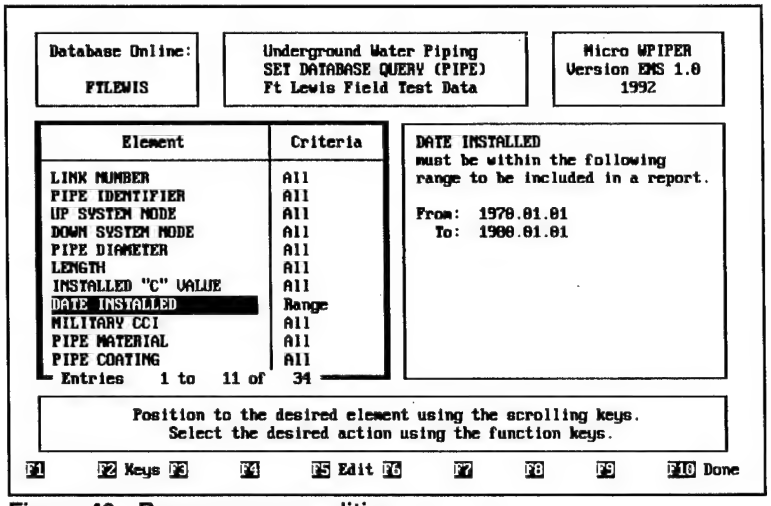


Figure 40. Range query condition.

When all queries are set and you have accepted them, press **[F10]**. You will be asked again if you wish to accept, modify, or quit the query section. After you have selected "accept," the SORT ORDER screen will appear. This option is currently not active. To bypass this screen, press **[F10]**, then press Accept **[A]**. Sort Order is currently set by using the procedure described under the Data Specification report.

Queries remain in force until they are changed. They remain active from report to report. They are also saved to disk, so the queries that are in force when you exit from WPIPER will still be in force the next time you use the program.

6.3 Database Related Reports Menu Option [2]: Data Specification Report

This report allows you to generate custom reports that display selected data from the pipe, appurtenance, hydrant test, or repair database in columns across the page. You specify the data fields that you wish to include in the report, as well as the positioning of the columns across the page. A sample data specification sheet is included in Appendix D (p 119).

When you select the Data Specification Report from the menu, you will be presented with the DATA SPECIFICATION REPORT menu. Select the database for which you wish to generate the report. You may select the Pipe, Appurtenance, Hydrant Test, or Repair database.

The printer pop-up selection screen will appear next. Your selections will determine the number of fields that you can choose to include in the report. Respond as described at the beginning of this chapter.

The following description is for pipe data, but the same general procedure is used for each of the other types of data. The setup screen shown in Figure 41 will appear. The fields will be displayed from left to right across the report page in the order they are selected. Begin by selecting the field that you wish to appear in the leftmost column of the report. To select a field, position the highlighted selection bar over its name and press **[F3]**, "Add," (or **[+]**, the plus key, or **[Ins]**) to add the field to the report. Next, select the field that you wish to appear immediately to the right of the first field. After a field is selected, a number designating its position appears to the left of the field name. Follow this procedure for each field that you wish to include in the report. To delete a field from the report, press **[F4]**, "Delete," (or **[-]**, the minus key, or **[Del]**). The field numbers will be updated when a field is deleted.

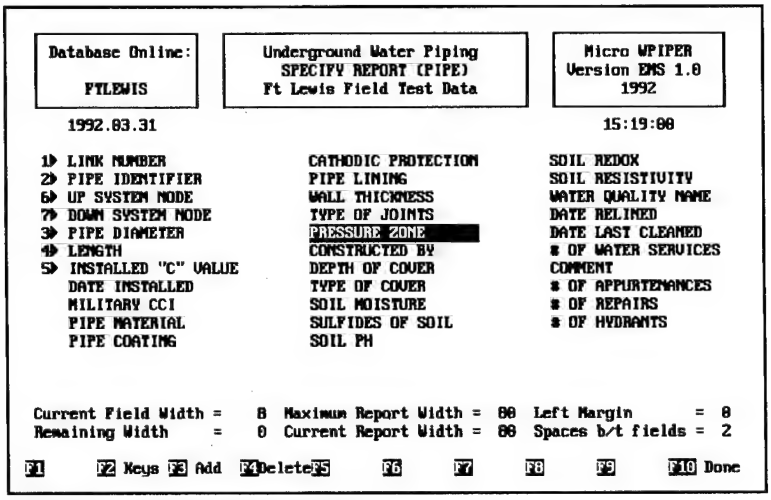


Figure 41. Specify report setup.

For assistance in configuring the report, refer to the status area at the bottom of the screen. This area is updated each time you add or delete a field. There is a maximum number of characters that can be displayed across the report page. This number is displayed in the Maximum Report Width field and will depend on the paper width and character pitch that you have selected. The Current Field Width gives the number of characters that will be taken up by the highlighted field (called the Current Field). The Remaining Width gives the number of spaces that are still available on the report page. Thus, if the Current Field Width is greater than the Remaining Width, there is not enough room to include the Current Field in the report. The Current Report Width gives the total number of characters that are in the fields you have already selected for inclusion in the report. The report Left Margin and number of spaces between reports are also displayed. Refer to Chapter 9 for details about how to change these values.

The Data Specification Report is subject to any queries previously set using the "Set Database Report Query" option described above. The default sort order for the listing of records in the Data Specification Report is in ascending order of Pipe Section IDs. An alternate order can be set by pressing **[ALT-I]**. The report statistics are removed from the screen and a bar reading **SET INDEX ORDER** is displayed as shown in Figure 42.

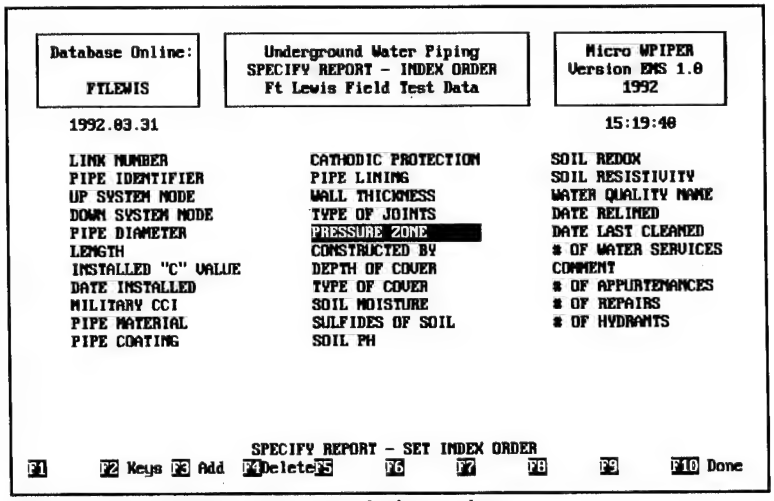


Figure 42. Specify report—set index order.

Select the field on which you wish to sort from the list by positioning the selection bar over it and pressing **[F3]**. Press **[F4]** to remove a field from the sort order. You may select up to five fields. Records will be sorted in ascending order. The first field that you select will be the primary sort criterion, the second field that you select will be the secondary sort criterion, and so on. Records will first be sorted according to the primary criterion. If there are several records with the same value for the primary criterion, those records will be further sorted using the secondary criterion. For example, suppose that Date Installed has been selected as the primary sort criterion, and Pipe Diameter has been selected as the secondary sort criterion. Therefore, the oldest pipe sections will be listed first in the report. For those pipe sections with the same installation date, the pipes with the smallest diameter will be listed first.

If LINK Number is chosen as a sort criterion, it should be chosen last since no further sorting is possible.

Press **[F10]** to exit **SET INDEX ORDER** and return to field selection.

When you are finished designing the report, press **[F10]** from the field selection screen. The "ACCEPT, MODIFY, QUIT" prompt will be displayed. If you accept the Specify

Report setup, the Printer Ready pop-up will appear. Press any key to begin printing the report.

6.4 Database Related Reports Menu Option [3]: AWADISO Data Validation Report

This report evaluates the completeness and integrity of the data that you have entered to make sure it meets input criteria for the hydraulic modeling module (AWADISO). The report flags errors (such as missing data) and explains what to do to fix them. This helps ensure an error-free run of the hydraulic modeling module. The Data Validation Report should always be generated before a hydraulic analysis is done. The report includes the following sections:

1. Summary of errors in the data
2. Total number of links, nodes, pumps, etc.
3. Tables of input data for links, nodes, appurtenances, and pipe aging
4. A detailed list of errors in the data with an explanation of how to correct them for each table of input data.

A sample AWADISO Data Validation Report is included in Appendix D (p 121).

6.5 Database Related Reports Menu Option [4]: Plot Flow Status Index Chart

This report produces a plot of the current and predicted C-factor and Flow Status Index (FSI) versus time for one pipe section. The Flow Status Index is explained in Appendix A (p 95). The report shows the degradation curve for unlined ferrous pipes. The information in the plot is also displayed in tabular form. The C-factor value obtained from field testing is also displayed.

When you select the Flow Status Index chart from the menu, you will be asked to select the LINK (pipe) for which you wish to generate the report. You may either type the number directly into the field, or you may select it from the pop-up list. To display the pop-up list, press **[F9]**). To select from the pop-up list, press **[F9]** again. Move the selection bar so that it highlights the LINK for which you wish to generate the report. Press **[ENTER]** to select it. If you do not wish to select from the pop-up list, press **[F10]** to return to the data entry field. After you have selected a pipe section, the printer control screen will appear. Respond to the prompts as described previously. A sample Flow Status Index Chart is included in Appendix D (p 126).

6.6 Database Related Reports Menu Option [5]: Condition Frequency Report

The Condition Frequency Report is a histogram that displays the number of pipe sections in various condition categories for the entire database. The overall condition of the network can be quickly and easily viewed with this report. Each pipe section in the database is assigned a condition class, from "excellent" to "failed." The number of pipe sections in each condition class is totalled and presented in the histogram. The percentage in each condition is also printed. The pipe sections are placed in a condition class according to the following criteria:

- FSI <20 = Failed
- FSI ≤29 = Very Poor
- FSI ≤39 = Poor
- FSI ≤59 = Fair
- FSI ≤69 = Good
- FSI ≤80 = Very Good
- FSI >80 = Excellent.

A sample Condition Frequency Report is included in Appendix D (p 129).

6.7 Database Related Reports Menu Option [6]: Priority Ranking Report

The Priority Ranking Report lists all of the pipe sections in the database in order of ascending C-factor/FSI. The pipe sections with the lowest C-factors are of obvious concern for maintenance planning and are listed first in the report. Low C-factors indicate that the flow capacity of the pipe has dropped considerably. This condition may interfere with fire flow capabilities and should be addressed. The Priority Ranking Report lists the link number, the FSI, and the pipe diameter.

To generate the report, simply select it from the menu and respond to the printer control screens as usual. A sample Priority Ranking Report is included in Appendix D (p 130).

6.8 Database Related Reports Menu Option [7]: C Value Worksheet Report

This report prints out a report that shows the LINK Number, material code, installed "C" value, current "C" value, base year "C" value, future year "C" value, and proposed "C" value. This report provides you with a data collection sheet for planning an aging analysis. The installed C value is the value that you have input into the Pipe Data

section of Data Entry and Modifications. The current, base year, and future year C-values are the values that have been predicted based on the existing information in the "Pipe Aging" option of Data Entry and Modifications. Thus, a base year and future year must be entered before this report can be generated. When you conduct C-factor tests in the field, record the results in the "proposed C-value" column. Then, use this sheet to update the "Last Measured C Value" column under the "Pipe Aging" option of Data Entry and Modifications.

To generate this report, select it from the menu and respond to the printer control screens as usual. A sample C-Value Worksheet is included in Appendix D (p 131).

6.9 Database Related Reports Menu Option [8]: Appurtenance Report

This report prints out the entire contents of the appurtenance database. This includes information on valves, hydrants, meters, and pumps. The Appurtenance Report will assist you in locating valves when the associated LINK Number is not known. The report may be used to determine spare part inventory requirements. Regular inspections of the appurtenances may be planned using the report, and a maintenance schedule prepared. This report lists everything but LINK Number data and fittings.

To generate the report, select it from the menu and respond to the printer control screens as usual.

6.10 Database Related Reports Menu Option [9]: Hydrant Trend Report

This report prints out the results of hydrant flow tests (as entered in the Hydrant Test section of Data Entry and Modifications) for one hydrant over time. As described previously, a proper implementation of WPIPER includes testing the condition of pipes and their ability to convey water. The tests involve flowing water from hydrants while measuring the pressures at other hydrants. The Hydrant Trend Report lists the results of the hydrant tests and calculations in a quick-reference table, and provides a chart showing hydrant performance with time. This report makes it easy to pinpoint areas that have deteriorated over time; if the out flow from a hydrant has decreased significantly, this area of the system should be studied to determine probable causes and cures.

To generate the report, select it from the menu. Select the pipe section (LINK) number and appurtenance (hydrant) number using the procedures described previously. Then respond to the printer control screens as usual.

6.11 Database Related Reports Menu Option [A]: Repair Report

This report displays the location, repair date, repair cost, repair method, and type of break for all of the repairs stored in the repair database. To generate the report, select it from the menu and respond to the printer control screens as usual.

6.12 Database Related Reports Menu Option [B]: Water Quality Database Report

This report displays a listing of all of the records in the water quality database. Each water identification will be listed, along with its complete chemical composition data. To generate this report, select option [B] from the DATABASE RELATED REPORTS menu and respond to the printer setup prompts as usual. A sample Water Quality Database Report is included in Appendix D (p 132).

7 Main Menu Option 3: Data Analysis Programs

This chapter explains the generation of reports that do not access information stored in the databases. The program option analyzes data that you enter. The DATA ANALYSIS PROGRAMS MENU is selected by choosing option **[3]** at the MAIN MENU. To run the Advanced Economic Analysis Report, select option **[1]**. To return to the main menu, select option **[E]**.

The Advanced Economic Report computes: (1) the life cycle cost and (2) the equivalent uniform annual cost per linear foot (EUAC/Ft) of a repair/replace alternative. The EUAC/ft is useful for comparing the per-foot cost of different alternatives. A sample report using the data entered in the following screens is presented in Appendix D. The initial Advanced Economics Analysis data entry screen requests general information such as the name of the alternative being analyzed, the length of the analysis period (in years), the interest rate, and the inflation rate.

Enter the data as prompted. When the last field is filled, the Accept, Modify, or Quit pop-up appears. To proceed to the next screen, press **[A]**. If you wish to change any of the information that you have just entered, press **[M]**. To return to the DATA ANALYSIS REPORTS menu, press **[Q]**.

In the next screen, the maintenance alternative being analyzed is broken down into one or more "M & R Activities." Each activity is subdivided into one or more "Components." Information to assist you in entering data is displayed below the program header. The left side of the help area contains a short description of the data entries required.

First, enter an alphanumeric description of the M&R Activity #1. Next, enter the cost data for the first component of M & R Activity #1. The FY entry is the year in which the activity is scheduled to be performed. The cost is in dollars. Timespacing refers to the amount of time in years that will elapse before this component activity will be performed again. For example, if the activity is scheduled biannually, enter a "2" in the timespacing field. Repeat this procedure until you have entered all of the components for M & R Activity #1.

To create M&R Activity #2 and all subsequent activities, enter a zero in the FY field and repeat the above procedure for entering component activities. When you are finished entering M & R activities, simply leave the description field blank. You will then be asked if you wish to print a detail report or a summary report (Figure 43). To print a detailed report, select **[D]**. To print a summary report, select **[S]**. Respond to the printer pop-up as explained at the beginning of the previous chapter.

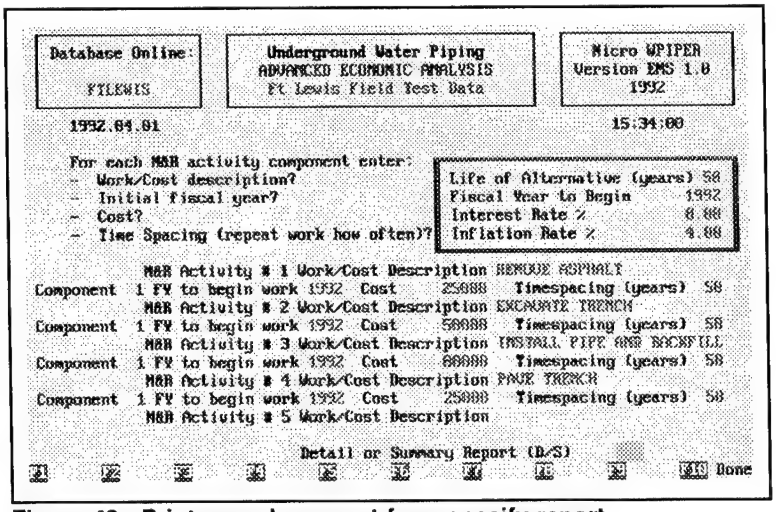


Figure 43. Printer ready prompt from specify report.

After the report has finished printing, you will be asked if you wish to analyze the same alternative using a different interest and/or inflation rate. If you wish to do this, press **[Y]**. If you wish to return to the DATA ANALYSIS PROGRAMS menu, press **[N]**.

8 Main Menu Option 4: Database Administration

This chapter will explain the procedures for creating, deleting, selecting, copying, and indexing databases. These functions are performed by selecting option **[4]** at the MAIN MENU. This displays the DATABASE ADMINISTRATION MENU as shown in Figure 44.

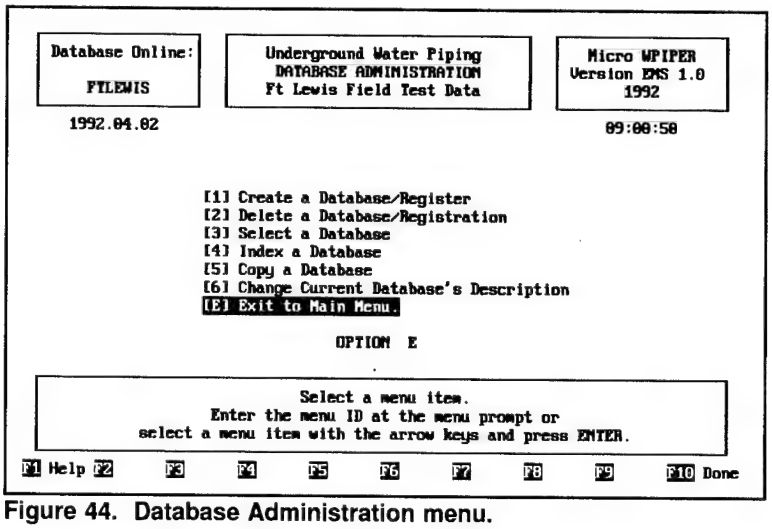


Figure 44. Database Administration menu.

8.1 General Instructions for Entering Directory and Database Names

Options **[1]** through **[5]** of the DATABASE ADMINSTRATION MENU require the entry of a path (drive and directory) and a database name. The instructions given in this section for entering the path and database are applicable to each of the menu options. Figure 45 shows the prompts that appear after a menu option is selected. The name of the menu option that you have selected is shown in the center box of the screen header.

There are several options for responding to the drive/directory prompt. If you wish to select the current directory path (typically, C:\WPIPER), simply press **[Enter]**. If you wish to select a different directory path, press **[F9]** to display a list of paths where WPIPER databases are already stored and registered (Figure 46).

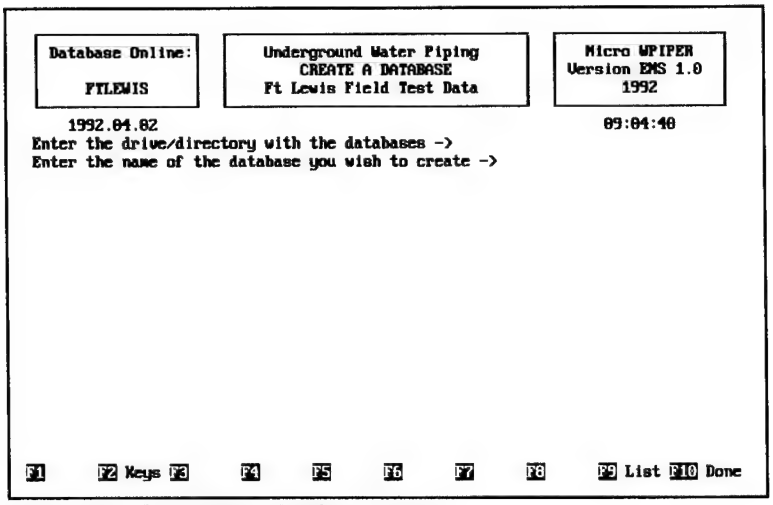


Figure 45. Database selection screen.

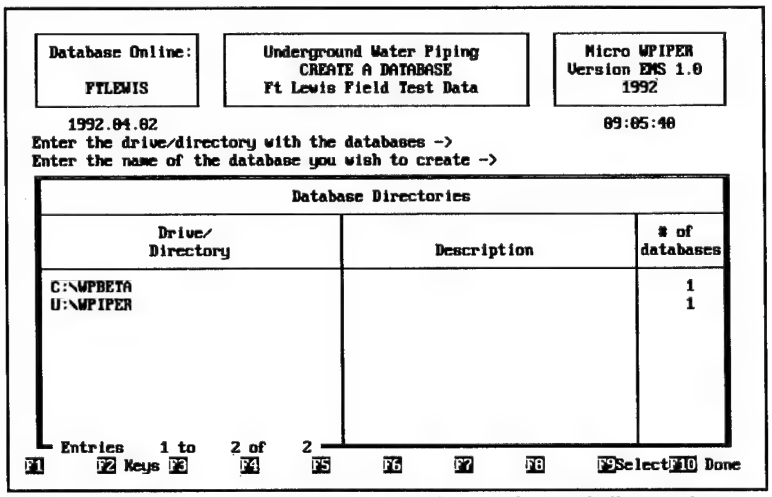


Figure 46. Pop-up window with list of unregistered directories.

If the list of paths is too long to fit in the pop-up window, press **[PgUp]** and **[PgDn]** to scroll through the pages of the list. If you wish to select one of the paths on the list, either type its name into the field, or press **[F9]** again to activate the highlighted selection bar (Figure 47). Using the cursor keys or space bar, position the selection bar over the name of the path and press **[Enter]** to select it. If you do not wish to select from the list, press **[F10]** to remove the pop-up window and return to the data entry field. If the path that you wish to select is not on the list, type its name into the field. Type both the drive and the directory (example: C:\WPIPER\DATA).

After you have selected a directory path, press **[F9]** to display a list of registered databases contained in the directory (Figure 48). If the list of databases is too long to fit in the pop-up window, press **[PgUp]** and **[PgDn]** to scroll through the pages of the list. If you wish to select one of the databases on the list, either type its name into the

field, or press **[F9]** again to activate the highlighted selection bar. Position the selection bar over the name of the database and press **[Enter]** to select it. If the database does not yet exist or is not registered with the program, you must type its name into the field since it will not be displayed on the list. The database name may be up to seven characters long.

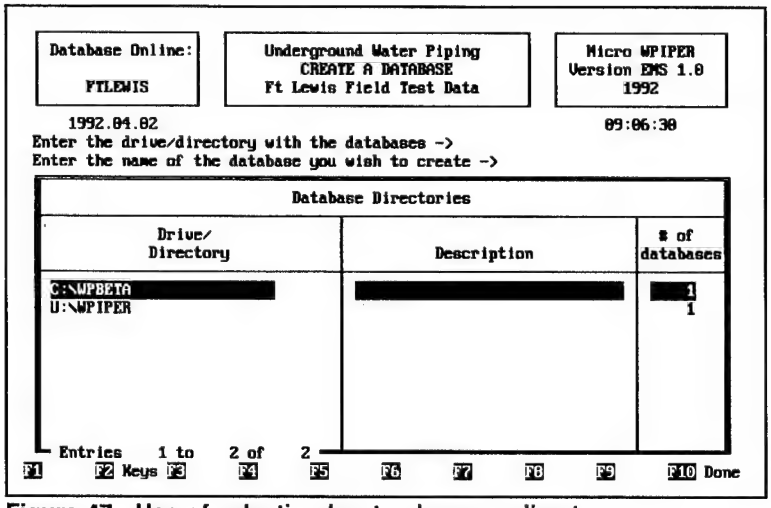


Figure 47. Use of selection bar to choose a directory.

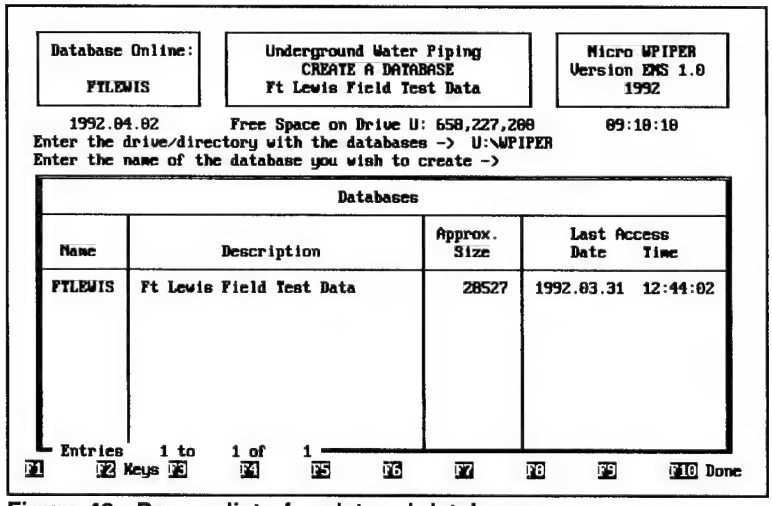


Figure 48. Pop-up list of registered databases.

To return to the DATABASE ADMINISTRATION MENU without choosing a database, press **[F10]** at any point on the directory and database selection screen. To obtain help with function keys, editing keys, and cursor movement keys during database selection, press **[F2]**. After the database is selected, the program proceeds to the action that you originally selected from the DATABASE ADMINISTRATION MENU.

8.2 Database Administration Menu Option [1]: Create/Register a Database

This option allows you to create a new database or to register an existing database with the program. Before any operations may be performed, a database must be selected for use. If no databases exist, as when WPIPER is first installed on a hard disk, one must be created.

When this option is selected, the CREATE A DATABASE MENU appears (Figure 49). This menu gives you the option of creating a new database or registering an existing database with the program.

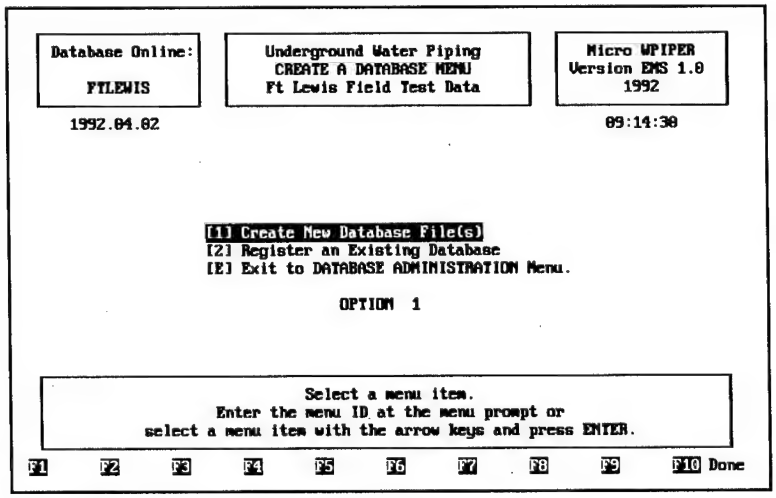


Figure 49. Create a Database menu.

8.2.1 *Create New Database File(s)*

This sub-option allows you to create a new database. Press **[1]** from the CREATE A DATABASE MENU. Creating a new database requires two input fields: the DOS path where the files are to be created and the name of the file. Follow the instructions given in Section 8.1, "General Instructions for Entering Directory and Database Names" to specify the directory path. If the directory does not exist, you will be asked if you wish to create it. After you have specified the directory path, enter a new database name at the prompt. (If you wish to see a list of existing databases, press **[F9]**). You will then be asked to enter a brief description of the database. The Accept/Modify/Quit screen will be displayed. If you choose **[A]**, the program will create the database (Figure 50). If you choose **[M]**, you will be allowed to modify the database description. If you choose **[Q]**, you will be returned to the menu and the database will not be created.

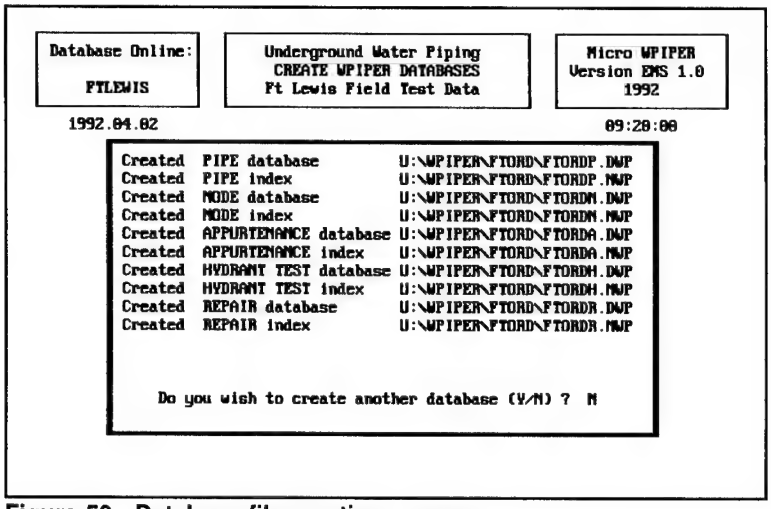


Figure 50. Database file creation process.

After you have created the database, enter a **[Y]** at the prompt if you wish to create another one. To return to the CREATE A DATABASE MENU, press **[N]** or **[ENTER]**.

8.2.2 *Register an Existing Database*

This option allows previously existing WPIPER database files to be accessed by the program. For example, files created on a different computer or with a different version of the program must be registered before they can be used. (Note that when a database is created as described above, it is automatically registered with the program.) The files must be copied onto the hard drive at the DOS level. On entering this section of the program, a screen similar to the CREATE A DATABASE screen will appear. Enter the path where the database resides into the first field (or select it from the pop-up list using **[F9]**). After you have specified the path and pressed **[ENTER]**, the cursor will move to the filename field. Enter the filename and database description. The database is now registered and available for use in the program.

8.3 Database Administration Option [2]: Delete a Database/Registration

This option allows you to delete database files. It operates similar to the "Create a Database" option. When you select this option, you will be asked to enter the DELETE password (Figure 51). After the correct password is entered, the DELETE A DATABASE MENU (Figure 52) will appear. There are two options available: to delete a database from the disk, or to remove the database's registration.

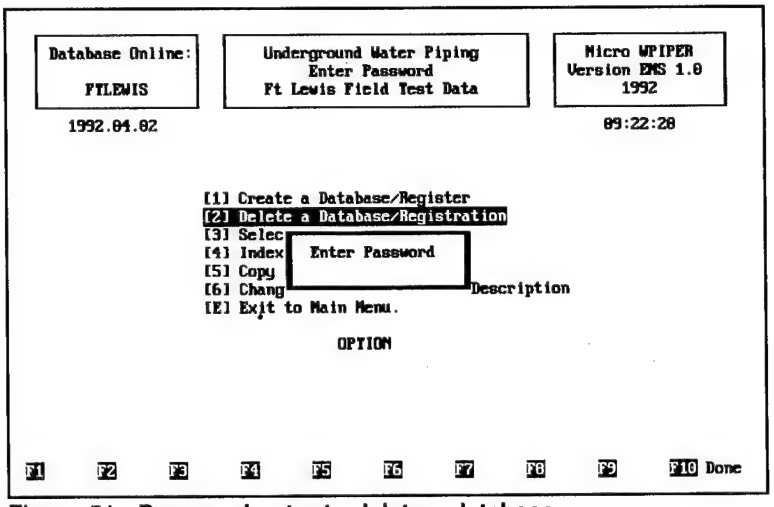


Figure 51. Password entry to delete a database.

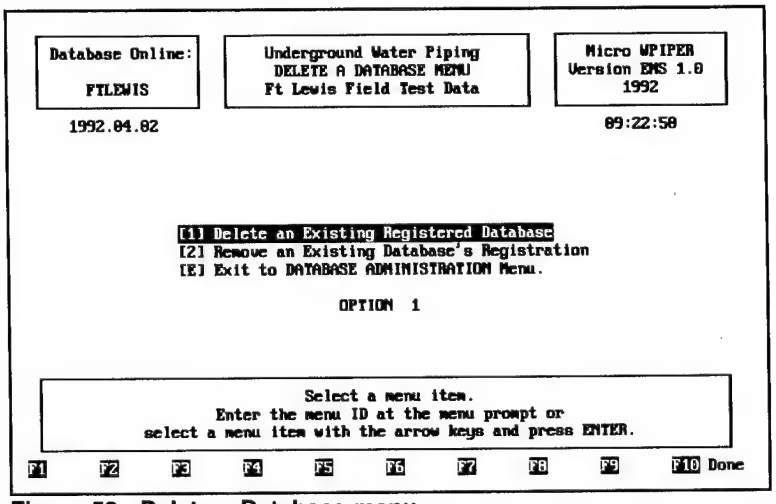


Figure 52. Delete a Database menu.

Deletion destroys the all of the data, including links, nodes, appurtenances, hydrant test records, and repair records. DO NOT use this option unless the data is no longer needed or a backup copy has been made. The removal of a registration from the database will not allow access to the data but does not destroy the data. The data will still be stored on the hard drive, and the database may be registered with the program at any time.

8.3.1 *Delete an Existing Registered Database*

When you select this suboption, the program prompts for the directory and database name of the file that you wish to delete. Select the directory path and database name using the procedures described in Section 8.1, "General Instructions for Entering

Directory and Database Names." You will be asked twice to confirm that you wish to delete the database (Figure 53). If you do not wish to delete the database, answer **[N]** at either of the prompts and you will be returned to the DELETE A DATABASE MENU. If you wish to delete the database, answer **[Y]** at both prompts. The database will be deleted and you will be asked if you wish to delete another database (Figure 54). If you wish to delete another database, answer **[Y]**, and the database selection screen will appear. If you do not wish to delete another database, answer **[N]** or press **[F10]**, and you will be returned to the DELETE A DATABASE menu.

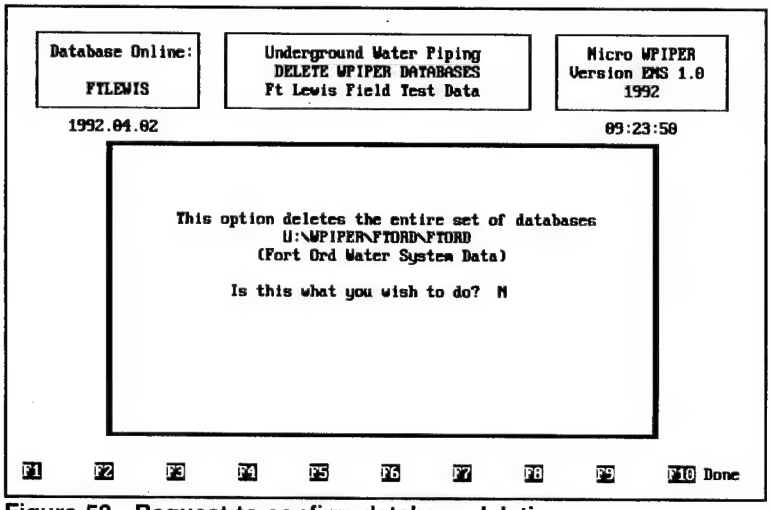


Figure 53. Request to confirm database deletion.

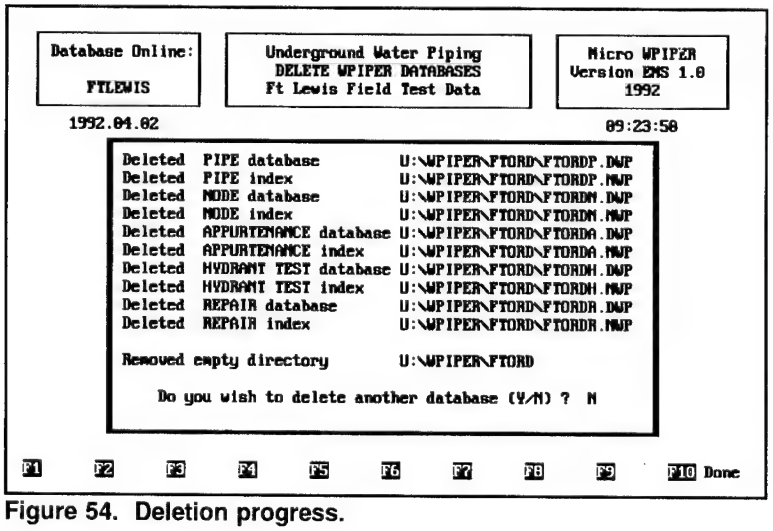


Figure 54. Deletion progress.

8.3.2 *Remove an Existing Database's Registration*

This option allows you to remove a database's listing from the program's internal tables. It does not erase the database from the disk. This option requires user

confirmation (Figure 55). The database can later be registered with the program again by using the "Register an Existing Database" option of the CREATE A DATABASE MENU.

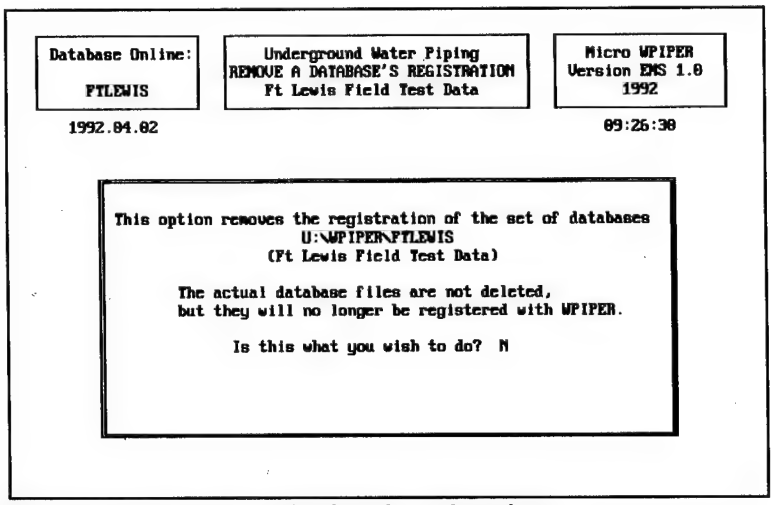


Figure 55. Removing a database's registration.

8.4 Database Administration Menu Option [3]: Select a Database

Before any file operations (such as entering data or printing reports) can be performed, a database must be selected for use (called the "active" database). This option allows you to select the active database. Select the directory path and database name using the procedures described in Section 8.1, "General Instructions for Entering Directory and Database Names." Figure 56 shows the database selection screen. The selected database is now ready for use. Other program functions, such as editing data and generating reports, may now be performed.

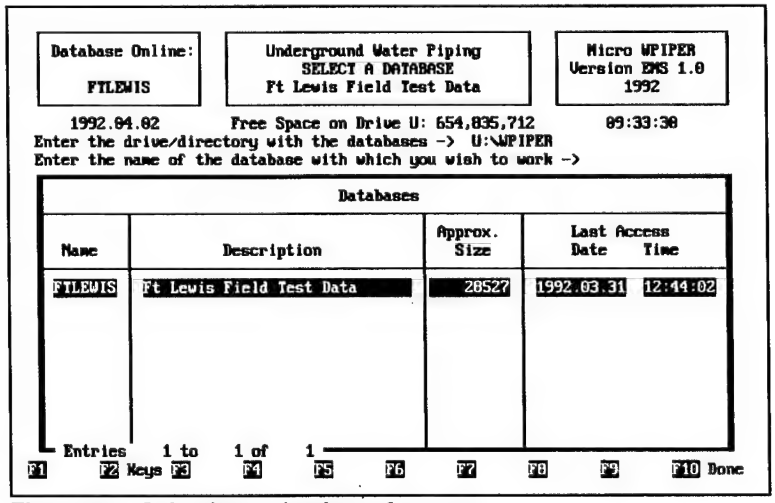


Figure 56. Selecting a database for use.

8.5 Database Administration Menu Option [4]: Index a Database

This option allows you to recreate all of the index files used by the selected database. Use this option if: (1) you accidentally delete the index files from your computer, (2) you copied the database files without the corresponding index files to another computer, (3) you have just added a large number of database records and wish to improve program efficiency, or (4) the index files have become damaged. The index files can be damaged if the power to your computer is interrupted or if you reboot your computer while you are working in WPIPER. When you choose this option, you will be asked to select the database that you wish to index. The active database is the default; to select it, simply press **[Enter]** at the directory and database file prompts. To select a different database, follow the procedures described in Section 8.1, "General Instructions for Entering Directory and Database Names." Next the program asks if you wish to create the index files for the database indicated. If you do not wish to recreate the index files, press **[N]** twice to return to the DATABASE ADMINISTRATION MENU. A **[Y]** will cause the system to create all of the index files.

Figure 57 shows the progress screen during indexing. Indexing can take a long time if the files are extremely large. After the index files have been created, press **[N]** or **[ENTER]** to return to the DATABASE ADMINISTRATION MENU. To index another database, press **[Y]**.

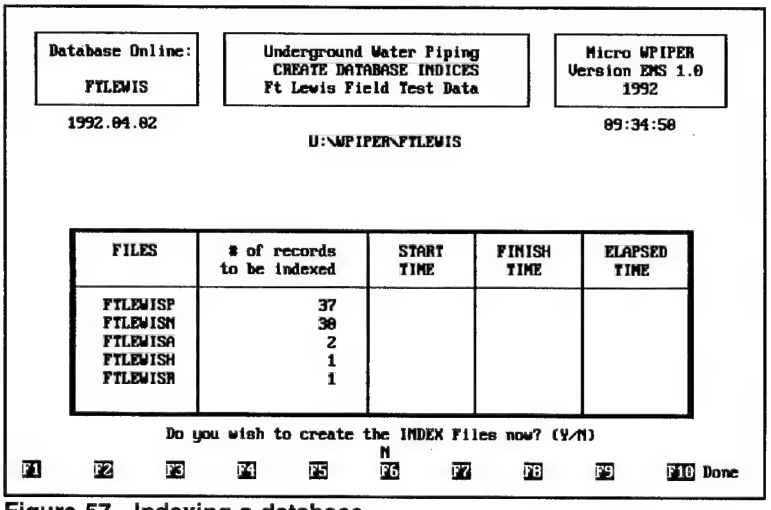


Figure 57. Indexing a database.

8.6 Database Administration Menu Option [5]: Copy A Database

This option allows you to copy a database to a diskette or to another hard drive and subdirectory. Databases may be copied to either 5.25 or 3.5-in. diskettes. Before you

select this option, make sure that the diskette or hard drive to which you plan to copy the files has enough space available to store them.

When you select this option, you will first be asked to specify the "source" database (i.e., the database that you wish to copy). To do this, follow the procedures described in Section 8.1, "General Instructions for Entering Directory and Database Names" (Figure 58). Next, you will be asked to specify the "destination" directory path and database name (Figure 59).

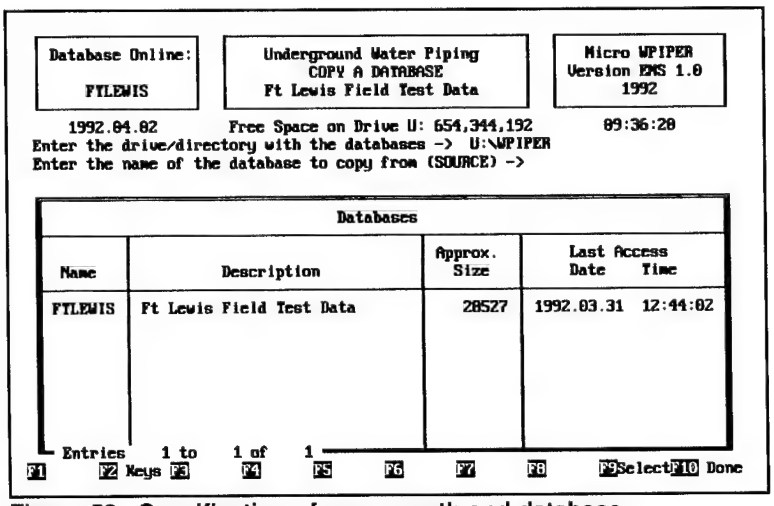


Figure 58. Specification of source path and database.

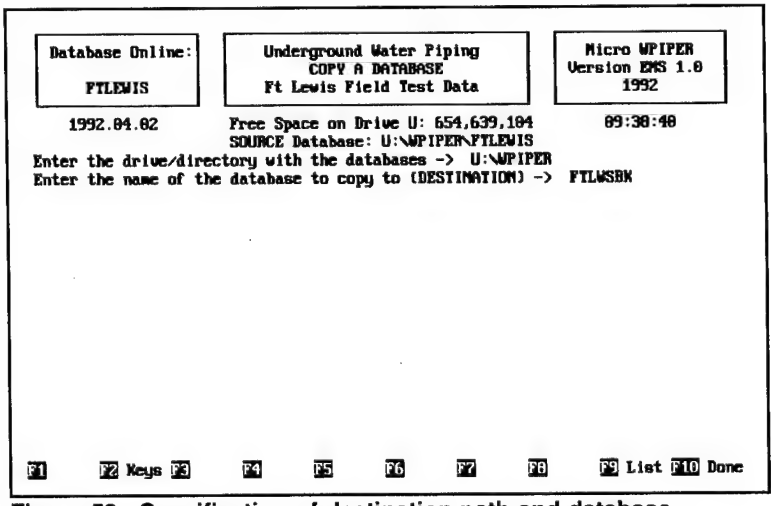


Figure 59. Specification of destination path and database.

The program then prompts for confirmation to perform the copy operation (Figure 60). Press [Y] to copy and [N] to return to the menu. After the database is copied, you are prompted to register the database for use by the system (Figure 61). This is only necessary when the file is being copied to the hard disk, therefore the program does

not automatically register the database. Press [Y] to register and [N] to return to the menu.

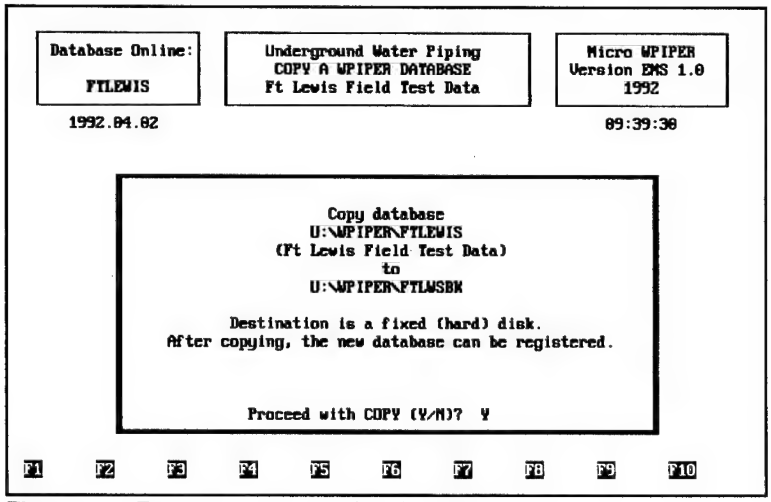


Figure 60. Request to proceed with copy.

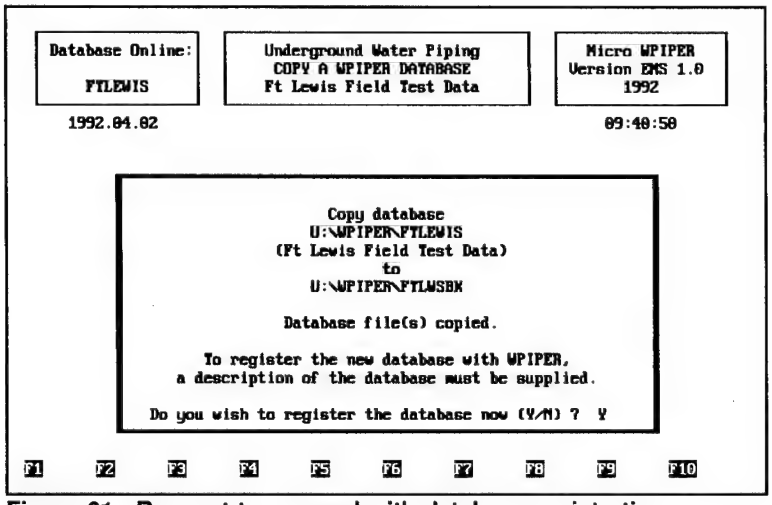


Figure 61. Request to proceed with database registration.

After registration of the newly copied database, you are prompted to index it. The database must be indexed before it can be selected for use. Answer [Y] to index the files. The index progress screen is shown in Figure 62.

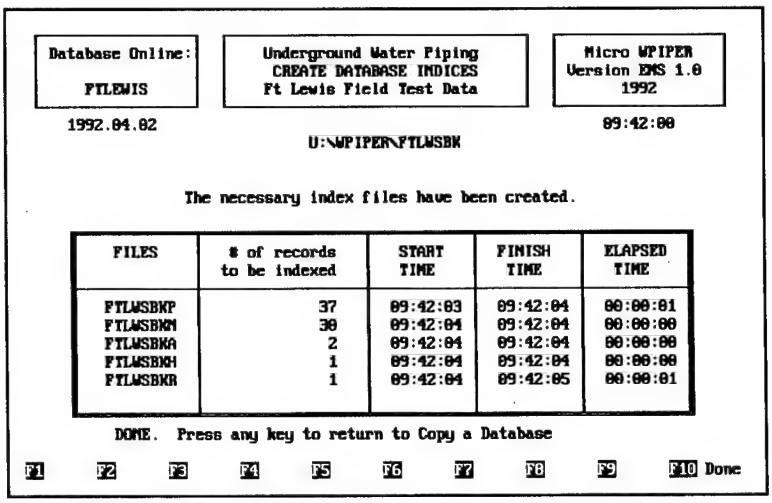


Figure 62. Indexing progress screen.

8.7 Database Administration Menu Option [6]: Change Current Database's Description

This option allows you to change the description of the currently selected database. When you select this option, you will be prompted to enter a brief alphanumeric description of the database. Enter the description and press **[Enter]** or **[F10]**. The Accept/Modify/Quit screen will be displayed. If you choose **[A]**, the program will save the new description. If you choose **[M]**, you will be allowed to modify the description. If you choose **[Q]**, you will be returned to the menu and the description will not be changed.

9 Main Menu Option 5: System Utility

This chapter discusses the System Utility functions. System utility functions allow you to perform a number of operations to configure WPIPER for your particular computer hardware and to customize the pop-up tables for your installation. The SYSTEM UTILITY MENU is shown in Figure 63.

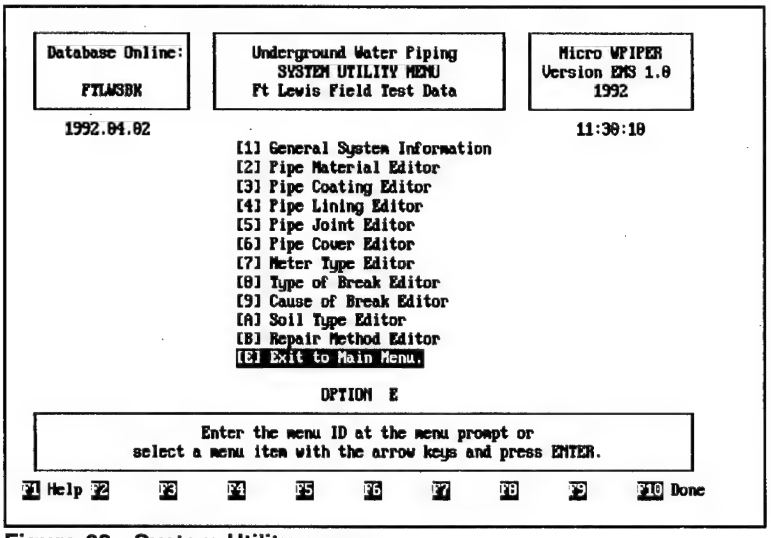


Figure 63. System Utility menu.

Since this program option allows access to all program features and allows you to change passwords, you must enter the appropriate password to gain entry to the edit screens. At the prompt, enter the System Utility password (Figure 64).

9.1 System Utility Menu Option [1]: General System Information

This selection allows customization of the program system for its hardware environment with five screens of user-definable options. Figure 65 shows the first display. Monitor type, passwords, and the default printer are set here. Printer, disk file, and system console characteristics for report output are set on subsequent screens. Press the **[PgUp]** and **[PgDn]** keys to move between the various screens. The screen available for each key is noted in a box at the base of the screen. Press the **[F10]** key to return directly to the SYSTEM UTILITY MENU from any screen.

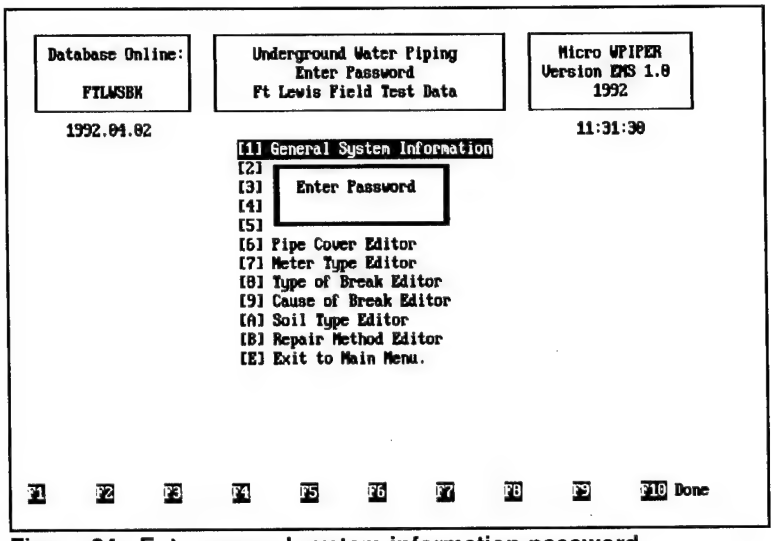


Figure 64. Enter general system information password.

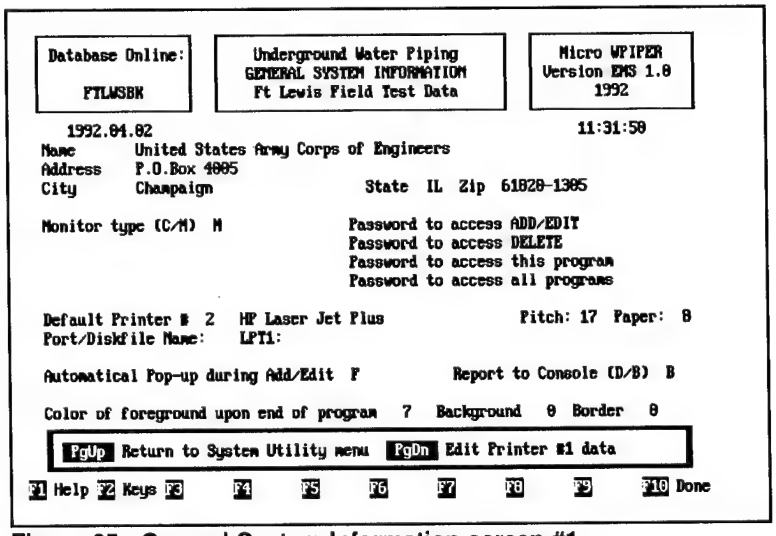


Figure 65. General System Information screen #1.

9.1.1 *User Name and Address (optional)*

Type your name, organization, and address in this section. This merely serves as a record and is not critical to the program's operation.

9.1.2 *Monitor type*

This section allows you to specify whether you are using a color monitor or a monochrome monitor. The initial setting is **[M]** (monochrome). Enter **[C]** (color) if the computer is equipped with a color monitor. If the monitor type is changed, the screen attributes are changed on exit from this screen.

9.1.3 *Passwords*

No passwords are set initially. The first password controls access to the Add/Edit operations of DATA ENTRY & MODIFICATIONS. New records may be added and data in existing records may be modified after you have entered this password. The second password controls access to the Delete operations. Deletion of records from a database or deletion of an entire database (or its registration with the program) requires the entry of this password. The entry of the "DELETE" password at the password pop-up prompt will also allow access to the Add/Edit operations. The third password controls access to General System Information and any System Utility editor (e.g., Building Category Code/Mission Priority). Therefore, if this password is forgotten, one cannot gain access to this screen to reveal it. The fourth password, if entered at any password prompt, allows access to all of the program's operations.

Once a specific password is entered correctly, the program will not prompt for it again during the current session. The password will be requested again after you have exited from the program and started it again at a later time.

Each password may be up to six characters in length. Enter the passwords of your choice at the prompts. It is recommended that the passwords be changed regularly to prevent unauthorized persons from gaining access to the data.

If any of the passwords are left blank, a warning message will be displayed both at program initialization and whenever the General System Information screens are exited.

9.1.4 *Default Printer #*

The initial setting for the default printer is **[1]**. Enter **[1]** or **[2]** to select which of the two possible system printers is to be the default. This printer will be highlighted in the Printer Prompt at report time.

The name of the default printer, its default pitch, default paper size, and port are displayed next to the printer #. Each printer has a separate setup screen where these options and other printer data may be entered.

9.1.5 *Colors on the End of the Program*

This option allows you to set the colors of the foreground, background, and border that will be in effect when you exit from WPIPER. The foreground color is initially set to white (7). The background and border are initially set to black (0). If the monitor type

(see above) is set to "C" (color), the program will set the screen border on a color monitor to blue. For information on the numerical designations for various colors, consult the documentation for your computer.

9.1.6 *Printer Information Screens*

There are four printer information screens. The first two screens contain printer settings. The third contains disk file specifications for report output. The last contains the system console characteristics, also for report output. These will be discussed in the following sections.

9.1.7 *Printers #1 and #2*

The initial settings for each of the fields on the Printer #1 and Printer #2 setup screens are shown in Figures 66 and 67. Printer #1 is initially set to an IBM Graphics Printer. This setup works with most Epson dot matrix printers (and printers that emulate the Epson). Printer #2 is initially set to an HP Laserjet II. The printer set-up fields are explained in the following paragraphs.

The Printer Name is an alphanumeric description of the printer that will appear in the printer prompt pop-up before a report is generated.

The Port is the DOS device name for the parallel port to which the printer is connected. Values may be set from LPT1: to LPT4: Serial printers may also be used, but you must configure DOS accordingly and provide the device name here. See the MODE command in the DOS manual and consult the printer's technical reference manual.

The Default Pitch value instructs the program which print pitch to use in terms of characters per inch (cpi). The available settings are 10 and 17 cpi. The appropriate setup string (defined below) will be sent to the printer when the report begins. The pitch setting also determines the left margin and, along with paper size, determines the maximum characters per line. (NOTE: The printer set-up screen allows for storing of data for four combinations of pitch and paper size. This field and the next field allow you to set a default combination, but any of the four combinations may be selected from the Printer pop-up at report time.

The Default Paper Size value informs the program of the size of paper in use by the printer. The available settings are **8** (for 8.5 x 11-in. paper) or **14** (for 14 x 11-in. paper).

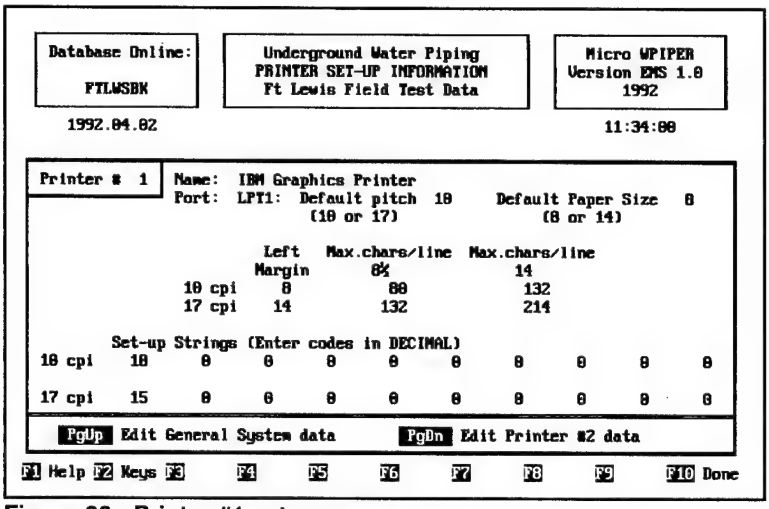


Figure 66. Printer #1 setup screen.

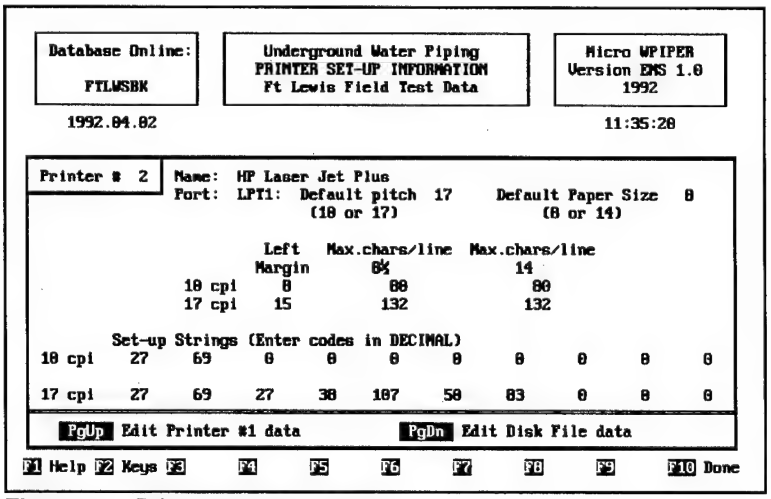


Figure 67. Printer #2 setup screen.

The Left Margin and Maximum Characters/Line field is where the left margin and maximum characters per line for both regular and wide paper are set. All units are in characters for the pitch selected. For example, a left margin of 8 for 10 cpi yields a 0.8-in. left margin. For a 1-in. left margin, set this value to 10. Since compressed print pitch varies from about 16 to 18 cpi depending on the printer, adjust the values for 17 cpi accordingly.

The Setup String fields allow you to enter the specific setup strings for 10 cpi (regular) and 17 cpi (compressed) print. Setup strings are unique to each model of printer. Consult the technical reference section of your printer's manual and enter the decimal ASCII values for each character in the required set-up string.

Up to 10 values may be entered to accommodate laser printers' long set-up strings. The program ignores values of zero.

9.1.8 *Disk File (PRINTER #3)*

Reports may be directed to a file on the hard drive instead of to a printer. The Disk File setup screen (Figure 68) allows you to set the Default Filename that will be displayed in the printer pop-up when you choose to save a report to a file. The inital setting for the file name is DISK.PRN. A name that is different from the default may be entered at report time. The extension is always fixed at ".PRN"

Initial settings of the other parameters are shown in Figure 68. These may be set accordingly if you wish to copy the disk file to the printer at a later time.

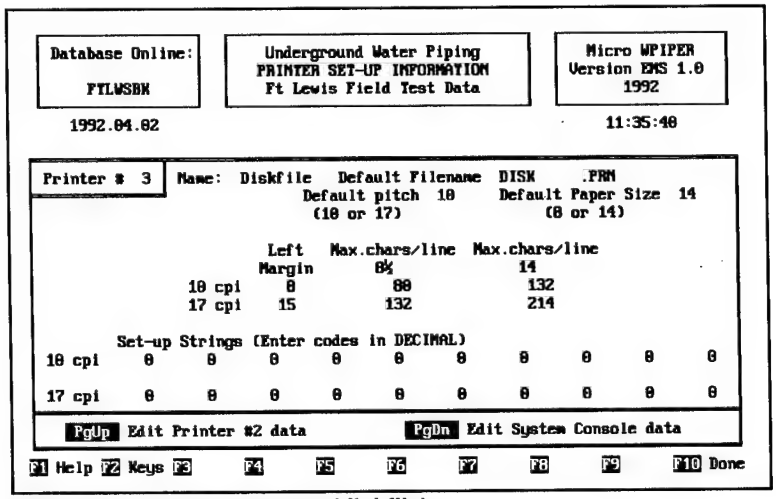


Figure 68. Printer #3 setup (diskfile).

9.1.9 *Console (PRINTER #4)*

Output may also be directed to the monitor. The Port is set to "**CON.**" This is the DOS device name for the system console. The other initial settings are shown in Figure 69. These may be changed to take of advantage of certain monitors' abilities to display more than 80 characters per line.

9.2 System Utility Menu Options 2 through B: Pop-Up Dialog Box Editors

The remaining options on the System Utility Menu allow you to edit the information in several of the pop-up dialog boxes that appear throughout the Data Entry and

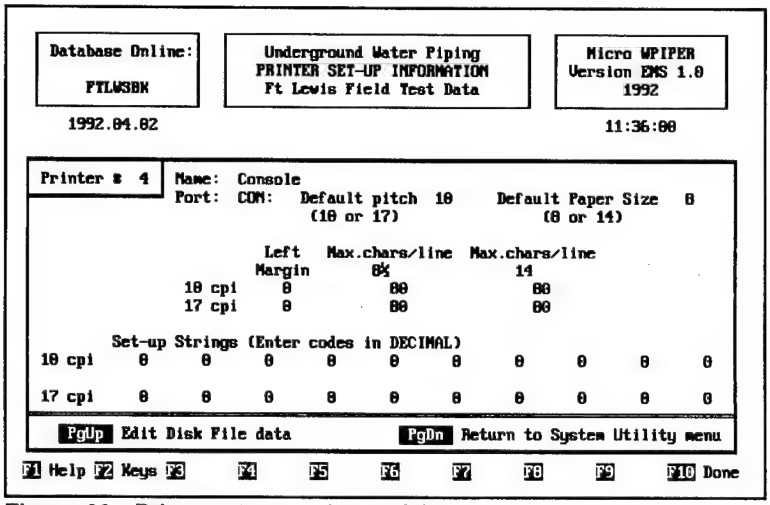


Figure 69. Printer #4 setup (console).

Modifications section of the program. This allows you to customize the pop-up boxes to your individual needs. There are editors for the following dialog boxes:

- pipe material
- pipe coating
- pipe lining
- pipe joint
- pipe cover
- meter type
- type of pipe break
- cause of pipe break
- soil type
- repair method.

After you select one of the editors from the menu, you will be prompted to enter a password. Enter the General System Information password. The data entry screen will appear (Figure 70). The figures in this section illustrate the Pipe Material Editor. The procedures for using the other editors are the same; only the data in them is different.

To add a new entry to the table, press **[F3].** The cursor will appear in the table after the last record and the words "<New Record>" will be displayed at the top of the screen between the date and the time (Figure 71). Enter the information that is requested in each column of the table. The record will be automatically positioned at the proper location (in alphabetic order) when the edited database is saved to disk. If you attempt to leave a required field (such as the material code) blank, an error message will appear as shown in Figure 72.

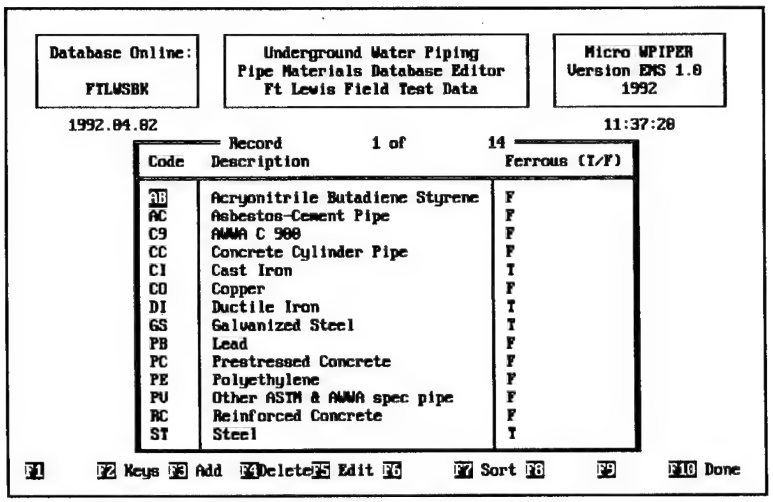


Figure 70. Pipe materials database editor.

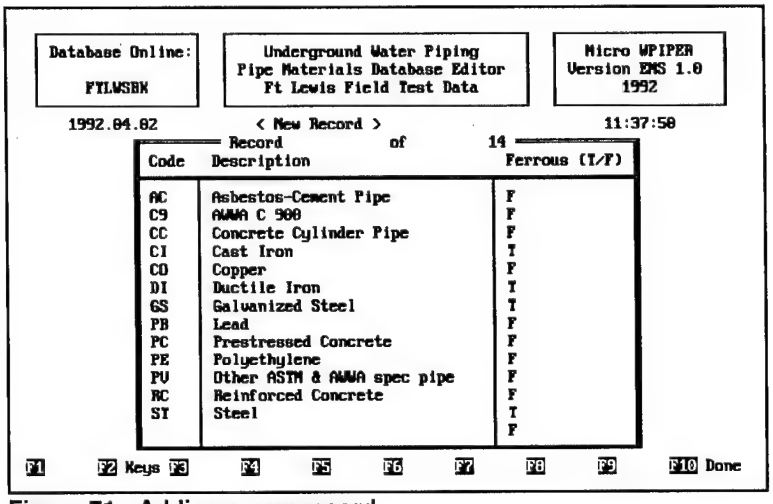


Figure 71. Adding a new record.

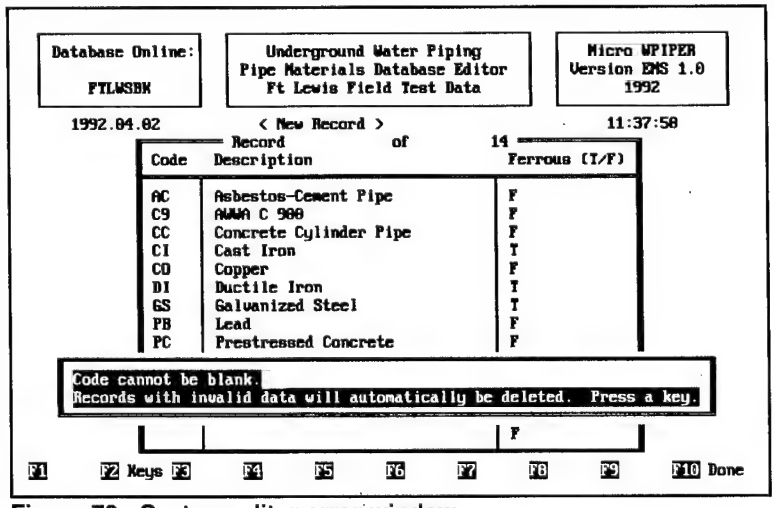


Figure 72. System editor error window.

If you wish to delete an entry from the table, position the highlight over it and press **[F4].** The words "<Deleted Record>" will be displayed between the date and the time (Figure 73). This notation will be displayed whenever the record pointer is positioned on a deleted record. A deleted record can be retrieved by pressing **[F4]** again.

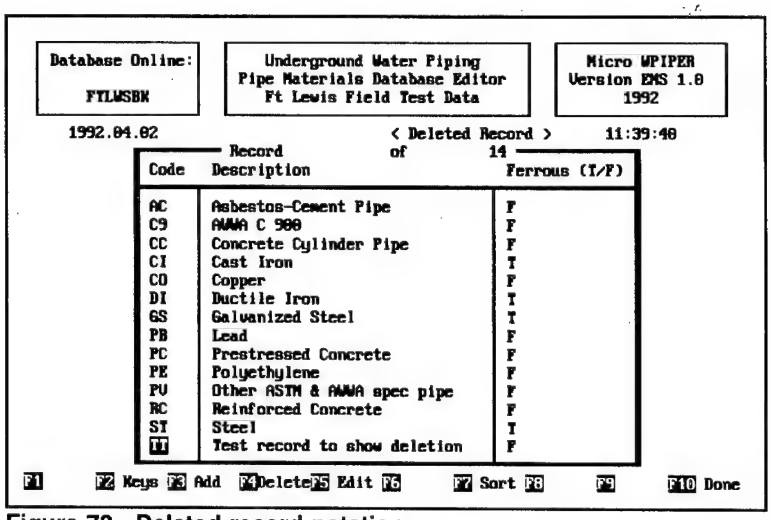


Figure 73. Deleted record notation.

To edit the entry at the selection bar, press **[F5]**.

Press **[F7]** to display the screen shown in Figure 74. If you answer, **[Y]**, the entries in the table will be sorted alphabetically according to the "Code" field, and records that have been tagged "<Deleted Record>" or that contain invalid data will be deleted permanently. This process is performed automatically when the edited table is saved to disk, but you may want to use this option to organize the data while editing.

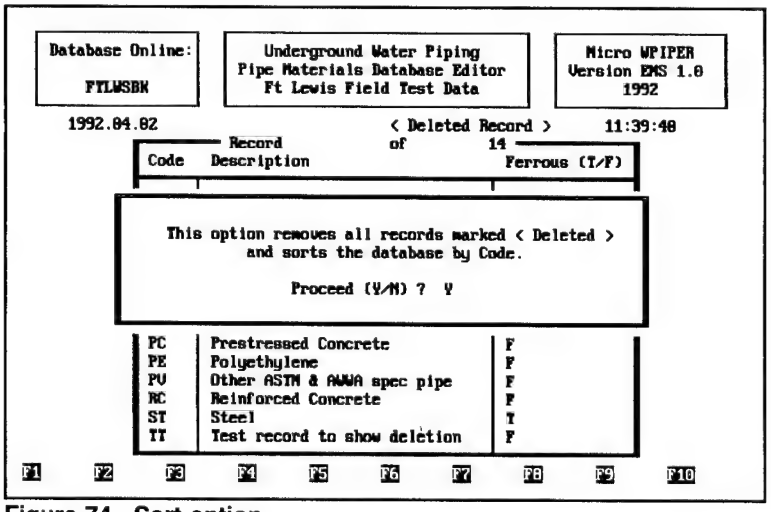


Figure 74. Sort option.

Press **[F10]** to conclude editing. You will be presented with the Accept, Modify, or Quit menu. To accept the edited table, press **[A]**. To return to editing, press **[M]**. To quit without saving what you have done, press **[Q]**.

10 Main Menu Option 6: AWADISO Menu

As discussed in Chapter 2, WPIPER includes the AWADISO hydraulic network analysis program. This menu option allows you to use AWADISO to perform hydraulic analysis of the water distribution system stored in the currently selected database. Figure 75 shows the AWADISO menu. Most of your work will be done with menu options [3] and [4].

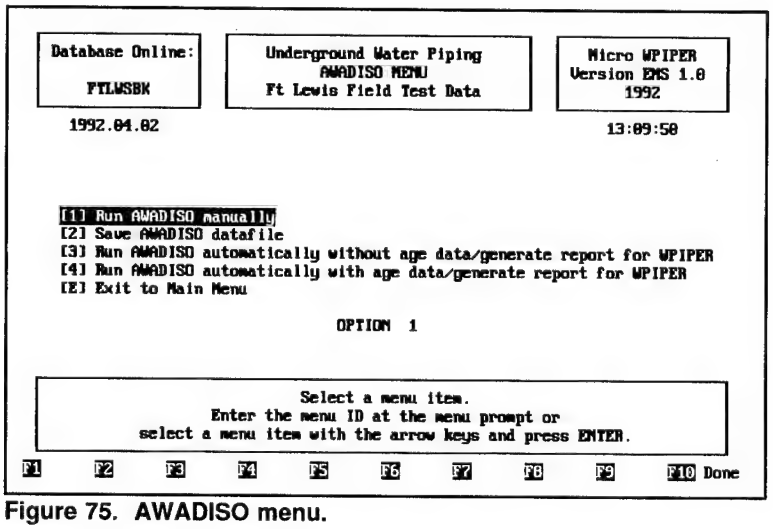


Figure 75. AWADISO menu.

The instructions for using the AGING features of AWADISO are included in this program as help screens and are accessible from the AWADISO MENU screen when the cursor highlight is on the **[3]**, **[4]**, **or [E]** item by pressing **[F1]**. This will bring up the first help screen. Pressing **[F1]** again will bring up the help index where the entire AGING addition to the WADISO Manual listed above is on line for immediate use.

10.1 AWADISO Menu Option [1]: Run AWADISO Manually

This menu option allows you to run the AWADISO program manually. The current data set will not be automatically sent to AWADISO, and no analysis will be performed unless you issue the proper AWADISO commands. Familiarity with the AWADISO program is required to use this menu option. Refer to the WADISO program

documentation for assistance. AWADISO documentation is contained in Engineer Manual (EM) 1110-2-502, Part 2, Change 6.

When you select this option, the AWADISO program will be initialized immediately. Enter AWADISO commands as usual. When you are ready to return to WPIPER, terminate AWADISO. You will be returned to the AWADISO menu.

10.2 AWADISO Menu Option [2]: Save AWADISO Data File

This option allows you to save the currently selected WPIPER data file as an AWADISO file. The file can then be retrieved directly from the AWADISO program when you are running AWADISO in the manual mode (menu option [1], discussed above).

When you select this option, you will be asked to enter the name of the AWADISO file that you wish to save. Enter a filename of up to eight characters plus a three-character extension (e.g., FTLEWIS1.VIC). At the next prompt, enter a brief description of the file. The description will be printed at the top of AWADISO report pages that you generate using this file.

10.3 AWADISO Menu Option [3]: Run AWADISO Automatically Without Age Data/ Generate Report for WPIPER

This option allows you to automatically send the current data set to AWADISO, perform a hydraulic analysis, and return a report of the analysis. The "Installed C-Value" that you input in the UPDATE PIPE DATA section of DATA ENTRY AND MODIFICATIONS will be used in the hydraulic analysis. The piping system WILL NOT be aged.

To perform this option, simply select it from the menu. After the analysis has been performed, the printer control screens will appear. Respond to them in the usual manner.

If there are errors in the data set that prevent AWADISO from performing a hydraulic analysis, a screen similar to Figure 76 will appear asking whether you wish to generate a Data Validation Report. You should generate the report to help you pinpoint the source of the error. Additional details on this report are given in Chapter 6, "Database Reports."

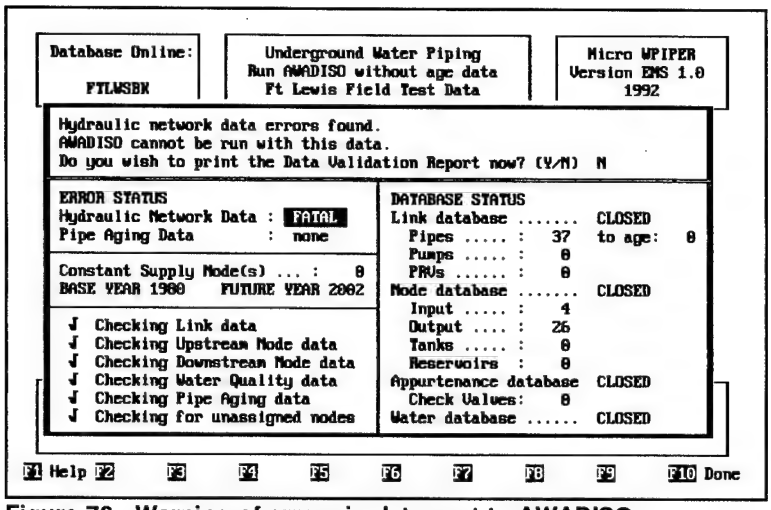


Figure 76. Warning of errors in data sent to AWADISO.

Note that even if you do not wish to age the system, you must still enter Base and Future years as described previously. The program will not send data to AWADISO unless you have entered this information and you will receive an error message. Go to Menu Item 1, "Data Entry & Modification" menu item, and press 6 to enter Aging Data. Enter the Base and Future years to use in future analysis. When these fields are filled, this program option will operate correctly.

10.4 AWADISO Menu Option [4]: Run AWADISO Automatically With Age Data/ Generate Report for WPIPER

This option allows you to automatically send the current data set to AWADISO, perform a hydraulic analysis, and return a report of the analysis. The piping system will be aged according to the information that you have input into the UPDATE PIPE AGING DATA section of DATA ENTRY AND MODIFICATIONS. The analysis that is generated will be for the year that you have specified as the FUTURE YEAR.

To perform this option, simply select it from the menu. After the analysis has been performed, the printer control screens will appear. Respond to them in the usual manner.

As with Option [3], If there are errors in the data set that prevent AWADISO from performing a hydraulic analysis, a warning screen will appear and ask whether or not you wish to generate a Data Validation Report.

A sample report showing an aged system is given in Appendix D (p 138).

11 Conclusion

The WPIPER 1.0 Engineered Management System provides Army installations with tools for cost-effectively maintaining carrying capacity in unlined metallic water distribution systems. A step-by-step procedure for implementing the program has been developed. The program allows the user to implement a forward-looking, proactive maintenance strategy instead of simply reacting to problems as they occur. Complete physical information about the water distribution system is at the user's fingertips in WPIPER's inventory databases. WPIPER stores data on hydrant tests, failures, and repairs so that distribution system performance can be tracked over time. The system incorporates the AWADISO hydraulic modeling program so that pressures, flow rates, and head losses throughout the distribution network can be calculated. A Hazen-Williams C-factor prediction model is included in the program so that pipe flow restriction can be forecast and it can be determined when each section of the system will no longer meet fire flow requirements. When a problem is detected or predicted, WPIPER can simulate various repair and replacement options so their technical and economic feasibility can be evaluated and compared. Future budget requirements can be planned and justified using the output from the WPIPER program.

References

American Water Works Association (AWWA), *Sizing Water Service Lines and Meters*, Manual M22 (AWWA, 1975).

Army Technical Manual (TM) 5-813-5, *Water Supply, Water Distribution* (Headquarters, Department of the Army [HQDA], November 1986).

Bandy, J.T., and R.J. Scholze, *Distribution of Water Use at Representative Fixed Army Installations,* Technical Report (TR) N-157 (U.S. Army Construction Engineering Research Laboratory [USACERL], August 1983).

Boland, J.J., D.D. Baumann, and B. Dziegielewski, *An Assessment of Municipal and Industrial Water Use Forecasting Techniques*, Report CR-81-C05 (U.S. Army Institute for Water Resources, 1981).

Clark, J.W., W. Viessman, and M.J. Hammer, *Water Supply and Pollution Control* (IEP–Dunn-Donnelley Publishing, 1977).

Engineer Manual [EM] 1110-2-502, Part 2, Change 6, *Methodology for Areawide Planning Studies* (Headquarters, U.S. Army Corps of Engineers [HQUSACE], 1 March 1988).

Engineer Technical Letter [ETL] 1110-2-297, *Evaluation of Existing Water Distribution Systems* (HQDA, 20 June 1986).

Langowski, J.F, L.E. Lang, J.T. Bandy, and E.D. Smith, *A Survey of Water Demand Forecasting Procedures on Fixed Army Installations*, TR N-85/07 (USACERL, 1985).

Linaweaver, F.P., J.C. Geyer, and J.B. Wolff, *Summary Report on Residential Water Use Research Project,* Journal of the American Water Works Association, vol 59, No. 3 (March 1967).

Military Handbook [MIL-HDBK]-1008B, *Fire Protection for Facilities: Engineering, Design, and Construction* (Department of Defense [DOD], 15 January 1994).

Walski, Thomas M., Wayne W. Sharp, and F. Douglas Shields, Jr., *Predicting Internal Roughness in Water Mains*, Miscellaneous Paper EL-88-2 (U.S. Army Waterways Experiment Station [USAWES], February 1988).

Walski, Thomas, *Analysis of Water Distribution Systems* (Van Nostrand Reinhold, 1984).

Williams, S.G., and A. Hazen, *Hydraulic Tables* (John Wiley and Sons, 1920).

Appendix A: Prediction Model Used in WPIPER

Background Information on Hazen-Williams C-factor

The C-factor is the factor in the Hazen-Williams equation that indicates the roughness of the pipe interior. It enables the engineer to estimate the amount of head loss that occurs in a given length of water pipe. The Hazen Williams equation is commonly written in the following form:

$$V = 0.55\ C\ D^{0.63}\ S^{0.54} \qquad \text{[Eq A1]}$$

where:

D = Inside diameter of pipe, ft
V = Velocity of water flow, ft/second
S = Hydraulic gradient h/L (head loss per length of pipe), ft/foot.

The velocity and head loss in this equation can be measured in the field using hydrant testing equipment. The testing procedure is discussed in Appendix C.

The C factor is related to the absolute roughness height inside the pipe, e. The linearized equation for the Hazen-Williams C factor is:

$$C = 18.0 - 37.2 \log\left(\frac{e}{D}\right) \qquad \text{[Eq A2]}$$

where:

e = Absolute roughness height, ft
D = Inside diameter of pipe, ft
C = Hazen-Williams C-factor.

How WPIPER Handles Pipe Aging

The aging of pipes in WPIPER involves predicting the Hazen-Williams C-factor for a user-specified future year. The actual aging of the pipes is carried out by the

AWADISO hydraulic analysis module. The main WPIPER program prepares the data for AWADISO and configures it into the form that AWADISO requires.

AWADISO's aging procedure is based on a "Base Year" and a "Future Year." The Base Year is the year in which C-factors have been measured or reasonably estimated. The Base Year can be the current year, or it may be a year in the past. The Future Year is the year to which you wish the system to be aged. Obviously, the Future Year must be later than the Base Year.

AWADISO assumes that all pipes in the network have the same Base Year. Thus, the C-factors that WPIPER sends to AWADISO must all be for the same year (Base Year). It is unlikely that all pipes in the WPIPER database will have C-factor data for the Base Year. Thus, WPIPER ages each pipe to the Base Year before sending the data to AWADISO. This way, each pipe in the WPIPER database may have its own unique installation date and C-factor measurement date.

The aging process in WPIPER/AWADISO operates as follows:

Step 1: Specification of Base and Future Years

You will need to enter a Base Year and a Future Year into WPIPER. The Base Year must be later than or equal to the installation year of the most recently installed pipe.

Step 2: Specification of Aging Method

For each pipe to be aged, you will need to specify the aging method that you wish to use in the "Aging Method" column of the EDIT WADISO AGE DATA table (Figure 26). You do not need to use the same method for every pipe in the database; you may use a combination of the methods depending on the data that is available. The three methods available are LANG, HAZE, and ALPHA. The LANG method uses water chemistry data to predict the roughness growth rate and future C-factor. You may use the LANG method if you know the Langelier Index (LI) of the water conveyed by the pipe, and if the LI is less than zero. The LI is calculated from the water's pH, temperature, total dissolved solids concentration, calcium concentration, and alkalinity. The HAZE method uses field-measured C-factor data to predict the roughness growth rate and the future C-factor. You may use the HAZE method if you have reliable field C-factor data available. The ALPHA method uses the roughness growth rate 'a' that you input. You may use the ALPHA method if you have determined the roughness of the growth rate. Most installations will use either the LANG or the HAZE method because the roughness growth rate 'a' is usually not known.

Step 3: Calculation of Roughness Growth Rate

WPIPER uses the aging method specified in step #2 to calculate the roughness growth rate, a, for each pipe section.

For the ALPHA method, enter the value of "a" (in feet) directly in the "Alpha Value" column of the EDIT WADISO AGE DATA table as shown in Figure 26. The program will then proceed directly to Step 4 and will use the "a" value that you entered in the C-factor calculation.

The HAZE method uses equation A3 to calculate "a". This method can be used when reliable field-measured C-factor data exists. Enter the field-measured C-factor for each pipe section in the "Last Measured C Value" column of the Edit WADISO AGE DATA table (Figure 26). This value is C_{AGE} in equation A3. Enter the age of the pipe (in years) at the time of the test in the "Age @ Test Time" column of the table. This value is t_{AGE} in equation A3. Enter the inside diameter of the pipe in the "Average Diameter" column. This value is D in equation A3. For example, suppose a 6-inch nominal diameter schedule 40 cast iron pipe was installed in 1960. A C-factor test was conducted in 1995, and it was determined that the c-factor was 70. You would enter "70" in the "Last Measured C Value" column. You would then enter "35" in the "Age @ Test Time" column. Next, you would enter "6" in the "Average Diameter" column, or if you wanted to be more precise, you would consult a piping specifications table to find the exact inside diameter (in this case, it is 6.065 inches).

$$a = \frac{D\left(10^{\left(\frac{18 - C_{AGE}}{37.2}\right)}\right) - 0.0006}{t_{AGE}} \qquad \text{[Eq A3]}$$

where:

C_{AGE} = Field-measured Hazen-Williams C-factor
D = Inside diameter of pipe, ft
t_{AGE} = Age of pipe when C_{AGE} was measured, years.

The "LANG" method uses equation A4 to calculate "a". The program automatically uses the value of the Langelier Index that has been entered into the Water Quality Database for each pipe. This equation is valid only for waters with Langelier Index less than zero.

$$a = 10^{-(4.08 + 0.38\ LI)} \qquad \text{[Eq A4]}$$

where: LI = Langelier Index of water conveyed by pipe.

Details on the development of the roughness growth rate equations have been previously documented (Walski, Sharp, and Shields 1988).

Step 4: Calculate Base Year C-Factor

WPIPER uses the calculated roughness growth rate, a, along with equation A5 below, to calculate the estimated C-factor for each pipe at the Base Year. For this calculation, T is the Base Year and T_1 is the year in which the pipe was installed.

$$C = 18 - 37.2 \log \left[\frac{a\,(T - T_1) + D\ 10^{\left(\frac{18-C_1}{37.2}\right)}}{D} \right] \qquad \text{[Eq A5]}$$

where:

C_1 = C-factor in year T_1
C = Predicted C-factor in year T.

Step 5: Transmit Information to AWADISO

For each pipe section, WPIPER sends the following information to AWADISO:

- Base Year C-factor (calculated in step #4)
- User-specified aging method (ALPHA, HAZE, or LANG), along with the data required by the specific method to make the aging calculation.

WPIPER also sends the specified "Base Year" and "Future Year" for the entire piping network.

Step 6: Age Pipe Network to Future Year

AWADISO ages the pipe network from the Base Year to the Future Year. It uses Equation A5 to predict the C-factor for each pipe in the Future Year. For this calculation, T is the Future Year, T_1 is the Base Year, C_1 is the C-factor for the Base Year as calculated in Step 4, and C is the predicted C-factor for the Future Year. Using the Future Year predicted C-factors, AWADISO performs a standard hydraulic analysis of the piping network.

Step 7: Transmit Results to WPIPER

AWADISO automatically returns the results of the hydraulic analysis to WPIPER.

Step 8: Generate Report

WPIPER generates a report of the results.

Step 9: Calculate Flow Status Index (FSI)

For consistency with other USACERL-developed maintenance management programs, WPIPER calculates a condition index on a 0 to 100 scale for each pipe section. This condition index is called the Flow Status Index (FSI) and is directly proportional to the C-factor as shown in Equation A6:

$$FSI = C/1.7 \qquad \text{[Eq A6]}$$

where C = the Hazen-Williams C-factor.

The FSI is used in the Flow Status Index Chart, the Condition Frequency Report, and the Priority Ranking Report.

Appendix B: Information Related to Setting up the Network

This Appendix contains:

1. An example of a piping network that has been broken up into links and nodes
2. A table explaining the fields in the pipe database
3. Data sheets to help you collect the information that needs to be input into WPIPER.

Figure B1 shows a sample water distribution system map. Figure B2 shows how the system from Figure B1 was broken down into Links and Nodes. Figure B3 shows how the buildings within the study area were assigned to nodes to calculate the demand requirements at each node. Table B1 showing the explanations of the pipe database fields follows the figures. Finally, there are blank data collection sheets for each of the WPIPER databases. You may photocopy these sheets to assist you in the WPIPER data collection process.

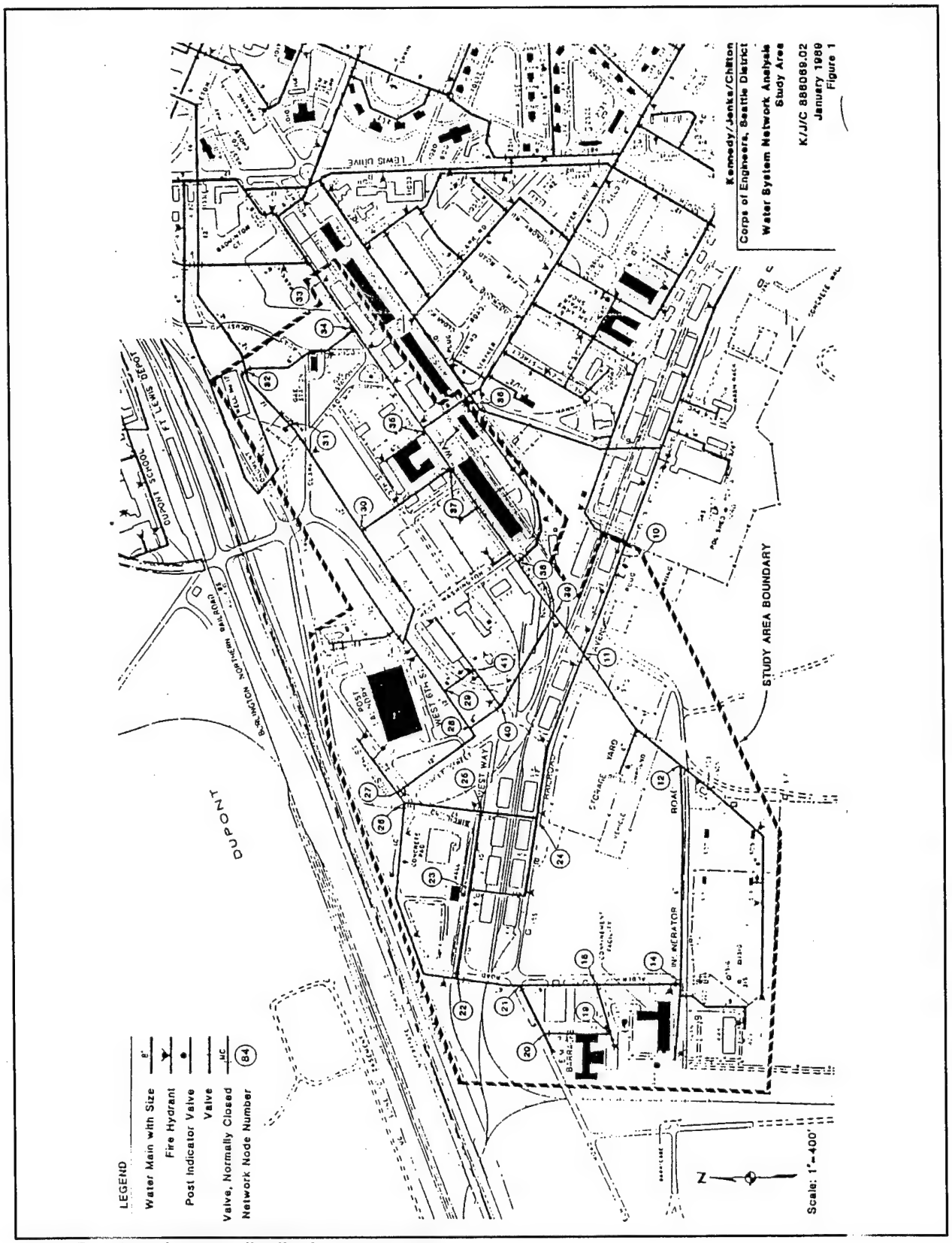


Figure B1. Sample water distribution system map.

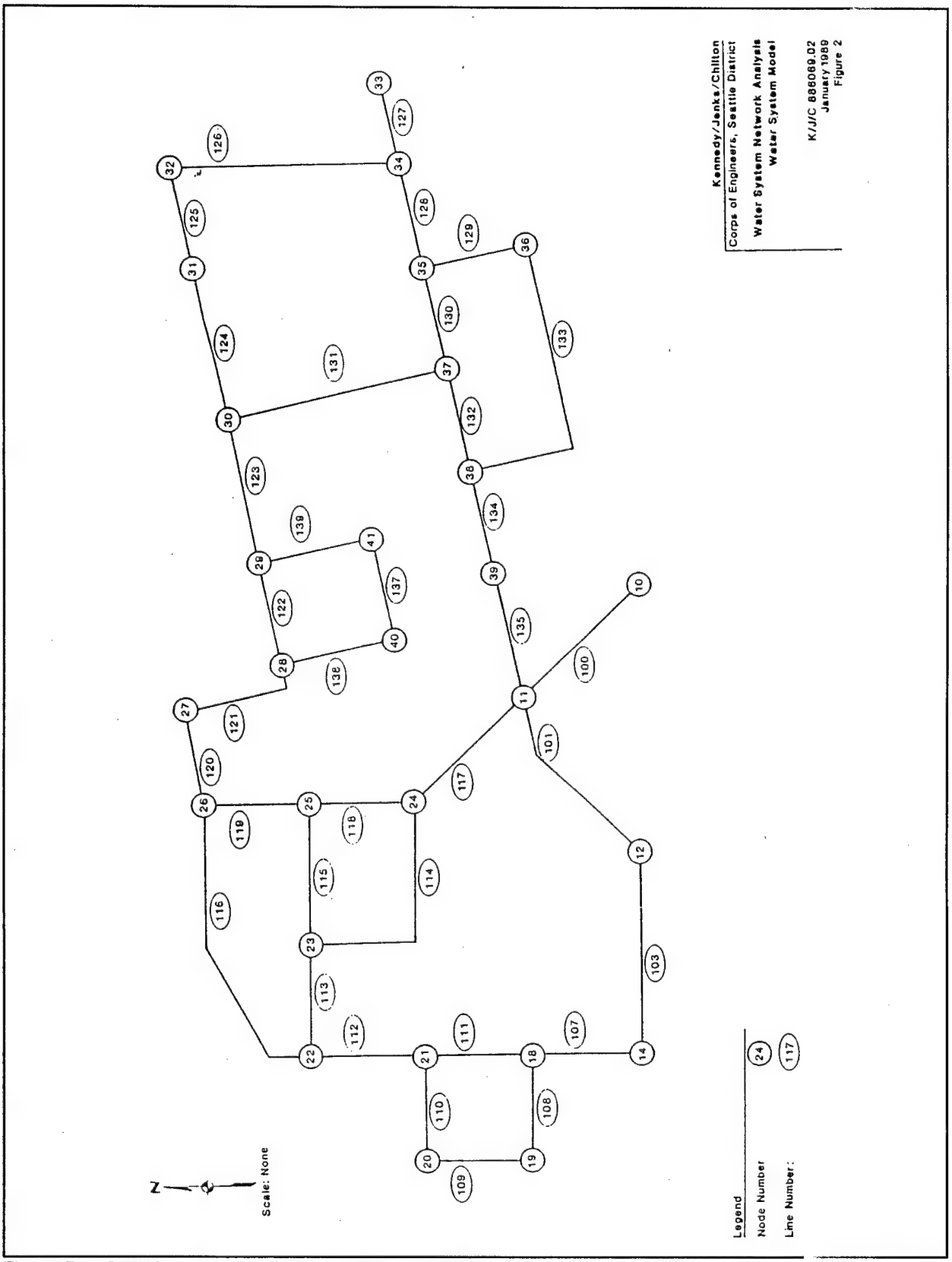


Figure B2. Sample water distribution system map broken into links and nodes.

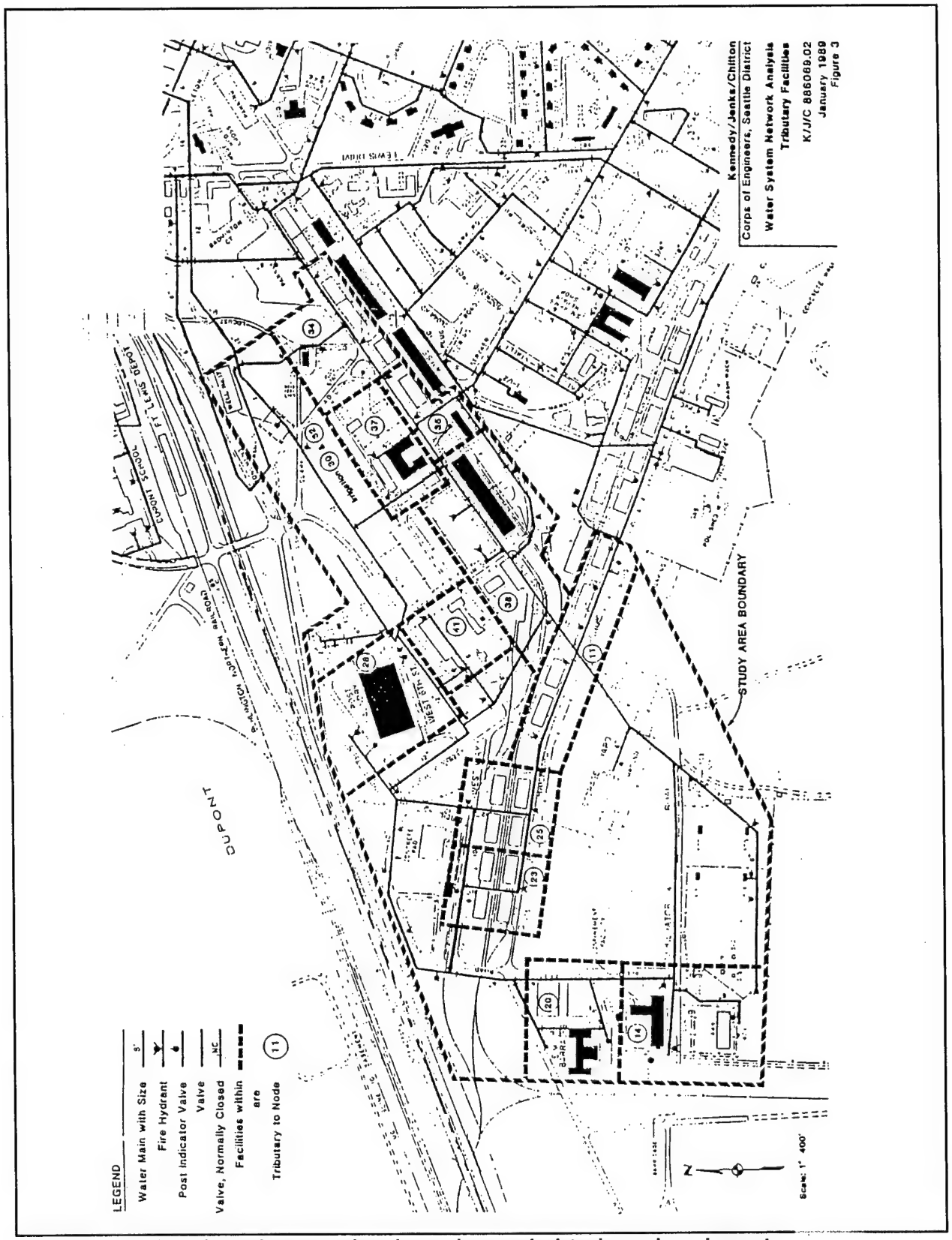


Figure B3. Buildings in study area assigned to nodes to calculate demand requirements.

Table B1. Pipe section database fields.

Field Name	Description of Data to be Entered
Link Number	This field contains the number which identifies the pipe segment. You do not have to start with 1; you may assign any number between 1 and 600. If there are 50 pipes, there are 50 link numbers. This aids in establishing what pipes are connected to which node (a location where pipes connect).
Pipe Identifier	This field is a 14-character alphanumeric field that is used to contain a short description of the pipe or its location. For example, "MESS HALL #1" would designate the pipe in front of Mess Hall #1. Since the field is only 14 characters, abbreviations will usually have to be used.
Up System Node	This field is used to designate the upstream node (end point) of the pipe section. In most cases the user will know the direction of the flow, so by specifying the upstream and downstream nodes, flow values will be positive in the printouts. If the nodes are reversed, the flow values will be negative.
Down System Node	The downstream node (end point) of the pipe section, as described above.
Pipe Diameter	This is the nominal diameter of the pipe in inches. In most cases, you will know the diameter of the pipe as 6 in., for example. The true inside diameter is a slightly different value, but this will have minimal effect in the analysis, so entering and using the nominal diameter is acceptable.
Length	The length in feet of the Link or segment.
Installed C Value	The clean, new pipe Hazen-Williams C-factor of this LINK Number. If you do not know this value, you may use values from the literature. Walski (1984) incudes information on C-factors for new pipe.
Date Installed	The date the pipe was installed in military format, YYYY.MM.DD. Note that it is possible to use the Installed "C" Value and Date Installed fields to advantage. For example, if a field investigation was conducted to measure C-factors, the measured values could be entered in the "C" Value field and the date of the investigation could be entered in this field.
Military CCI	This field is used to hold a construction cost index. The most common index to use is the Engineering News Record Construction Cost Index, usually abbreviated ENRCCI. It is published twice a month in the Engineering News Record Magazine. It is based on 100 in the year 1913. To estimate a cost from the past to today, obtain the current ENRCCI and divide by the installed ENRCCI. Multiply the past cost by the ratio to obtain today's cost.
Pipe Material	Enter the material of the pipe as shown in the pop-up dialog box.
Pipe Coating	Enter the material of the coating as shown in the pop-up dialog box.
Cathodic Protection	Enter a "T" (true) if the pipe is cathodically protected or "F" (false) if it is not.
Pipe Lining	Enter the material of the pipe lining as shown in the pop-up dialog box.
Wall Thickness	Enter the thickness of the pipe wall in inches. It is suggested that a table of values be prepared and kept handy to enter this data.
Type of Joints	Enter the type of pipe joints as shown in the pop-up dialog box.

Field Name	Description of Data to be Entered
Pressure Zone	Enter the pressure zone as shown in the pop-up dialog box. You will have to create the database records using the SYSTEM UTILITY Editors to enable the pop-up dialog box to display data. This is done by selecting [5] from the DATA ENTRY & MODIFICATION MENU.
Constructed by	Enter the contractor who installed this LINK Number as shown in the pop-up dialog box. You will have to create the database records for this pop-up dialog box. This is done by selecting [4] from the DATA ENTRY & MODIFICATION MENU.
Depth of Cover	Enter the depth of cover (fill) over this pipe.
Type of Cover	Enter the type of cover (fill material) as shown in the pop-up dialog box.
Moisture of Soil	Enter the approximate moisture of the soil in percent. This is helpful in evaluating the corrosiveness of the soil to the exterior of the pipe. This aids in making a decision to install cathodic protection.
Sulfides of Soil	Enter the sulfide concentration in mg/l of the soil if known.
Soil pH	Enter the soil pH if known.
Soil Redox	Enter the soil oxidation reduction potential in millivolts if known.
Soil Resistivity	Enter the soil resistivity in ohm-centimeters if known.
Water Quality Name	Enter the name of the water quality data base record associated with this pipe. The record must have already been created using option 3 under "Data Entry and Modifications."
Date Relined	Enter the military date when the pipe was relined.
Date Last Cleaned	Enter the date of the last cleaning of the pipe section.
# of Water Services	Enter the number of services connected to this pipe.
Comment	This field is 60 characters wide and can be used to record any information the user wishes about this length of pipe.

PIPE LINK DATA SHEET

Data **required** as input to WPIPER is denoted with an asterisk (*)

* Link (pipe) #: _____ Pipe identifier: _____

* From Node: _____ * To Node: _____

* Pipe Diameter (in.): _____ * Length (ft): _____

* Installed "C" value: _____* Date Installed (yyyy/mm/dd): ____/____/____

Military CCI: _____

* Pipe Material (circle one):

ABS Asbestos-Cement AWWA C900 Concrete Cylinder Cast Iron Copper Ductile Iron Galvanized Steel Lead Prestressed Concrete Polyethylene Other ASTM/AWWA spec pipe Reinforced Concrete Steel

Pipe Coating (circle one): Bituminous Concrete Coal Tar None Plastic wrapped

Is pipe cathodically protected (circle one)? Yes No

Pipe lining (circle one): Concrete Epoxy None Plastic

* Wall Thickness (in): _____

Type of Joints: Flanged Fusion Mechanical Joint--Rubber Push On Solvent Weld Threaded

Pressure Zone: _____

Constructed By: _____

Depth of Cover (ft): _____

Type of Cover: Asbestos-cement Bituminous Surface Treatment Concrete Gravel No pavement on dirt road Vegetated area Water

Moisture of soil (%): _____ Soil Resistivity (ohm-cm): _____

Sulfides of soil (mg/l): _____ *Water Quality Name: _____

Soil pH: _____ Date Relined: ____/____/____

Soil Redox (mv): _____ Date Last Cleaned: ____/____/____

# of Water Services: _____ Comments: _____

PUMP LINK DATA SHEET

All data is **REQUIRED** except for "Horsepower".

Link Number: _____

Upstream Node: _____

Downstream Node: _____

Enter points on pump performance curve. You may enter either 1 point or 3 points.

	Discharge, GPM	Head, ft.
Point #1		
Point #2		
Point #3		

Horsepower: _____

PRESSURE REDUCING VALVE (PRV) LINK DATA SHEET

Data **required** as input to WPIPER is denoted with an asterisk (*)

* Link Number: _____

* Upstream Node: _____

* Downstream Node: _____

Size (in.): _____

Manufacturer: _____

Headloss coefficient: _____

Upstream pressure (PSI): _____

* Downstream pressure (PSI): _____

Bypass size (in.): _____

APPURTENANCE DATA SHEET

Link Number: _____

Appurtenance Type (circle one):

Air release valve	Hydrant
Air/vacuum valve	Meter
Butterfly valve	Reduced pressure backflow preventer
Gate valve	Vacuum release
Globe valve	

Appurtenance Key: _____

Location (ft): _____

Size (in.): _____

Manufacturer: _____

Headloss coefficient: _____ (not needed for air release valve, air/vacuum valve, hydrant, vacuum release)

For Altitude Valves:

Upstream Pressure (PSI): _____

Downstream Pressure (PSI): _____

Bypass Size (in.): _____

For Hydrants:

Length to Hydrant (ft) _____

Isolation valve? Yes No Dry barrel hydrant? Yes No

For Meters:

Meter type: _____

For Reduced-Pressure Backflow Preventers:

# of Parallel Devices: _____ Min. Pressure Drop (PSI): _____

NODE DATA SHEET

Data **required** as input for WPIPER

Node #: _____

Elevation of center line of pipe at node (ft) _____

Node Type (circle one):

(1) Input (2) Output (3) Tank (4) Reservoir

Domestic Demand (GPM): _____

Fire Demand (GPM): _____

If Node is a Tank:

Water level above pipe center line (ft): _____

Tank size (gal): _____

IN SITU C FACTORS DATA SHEET

Field test data **required** to calculate C factor

Location: _____

	Hyd. #	Elev. (Ft)	Static P P_s (psi)	Flow P P_f (psi)	$\Delta P=P_s-P_f$ (Stat-Flow)	ΔP (ft)
Downstream						
Upstream						
Head Loss, h*	------	------	------	------		

* $h = [\text{Static P} - \text{Flow P}]_{\text{Downstream}} - [\text{Static P} - \text{Flow P}]_{\text{Upstream}}$

Equivalent to $h = \Delta P_{Flow} - \Delta P_{Static}$

Flow (Q), Q_f = _____ GPM From Hydrant #: _____

Static P, P_s =

Flow P, P_f =

Section Length (L) = _____

Diameter (D) = _____

Area (A) = _____ ft^2

$$V = \frac{Q}{448.8 * A} =$$

$$C = \frac{8.71 * V}{D^{0.63} * \left(\frac{h}{L}\right)^{0.54}} =$$

WATER QUALITY DATA SHEET

Items marked with an asterisk (*) are **required** by WPIPER

* pH:			
* Temperature (°C):		Silicate (mg/L) :	
Oxygen (mg/L) :		Sulfate (mg/L) :	
Carbon Dioxide (mg/L) :		Sulfide (mg/L) :	
Aluminum (mg/L) :		Silica (mg/L) :	
Copper (mg/L) :		Carbonate Hardness (mg/L) :	
Iron (mg/L) :		Total Hardness (mg/L) :	
Magnesium (mg/L) :		Methyl Orange Alkalinity(mg/L) :	
Manganese (mg/L) :		Phenolphthalein Alkalinity (mg/L) :	
Sodium (mg/L) :		Hydroxide Alkalinity (mg/L) :	
Calcium (mg/L) :		Carbonate Alkalinity (mg/L) :	
Tin (mg/L) :		Total Alkalinity (mg/L) :	
Zinc (mg/L) :		Total Dissolved Solids (mg/L):	
Chloride (mg/L) :		Conductivity (µmohs) :	
Chlorine (mg/L) :		*Langelier Index :	
Fluoride (mg/L):		Ryznar Index:	
Nitrogen (mg/L):		Aggressiveness Index:	
Phosphates (mg/L)			

CONTRACTOR DATA SHEET

Optional data for input to WPIPER

Name of Contractor: _____

Contact Person: _____

Address of Contractor: _____

City: _____

State: _____

Zip Code: _____

Phone #: _____

Work Quality Comments: _____

_____

_____

Military Contract #: _____

Year of Contract: _____

REPAIR DATA SHEET

Optional data for input to WPIPER

Link Number: _____

Repair Key: _____

Repair date (YYYY/MM/DD): _____

Repair Cost ($):

Sent to IFS? Yes No

Comment: _____

Litigation Cost ($): _____

Other Utility Costs ($): _____

Type of Break (circle one):

Corrosion hole Circumferential Break Crush from overburden or load Joint Packing Blow Out Longitudinal Break

Puncture Hole Split Bell Joint Crack Tap Leak

Failure cause (circle up to 2):

Adjacent Construction-related	Expansive Soil Break	Corroded Reinforcing Steel
Appurtenance Failure	Frost Break	Previous Repair Failure
Buried Structure Contact Footings	Bad Initial Construction	Surface Loading
External Corrosion: Stray current	Excessive Internal Pressure	Solvent Softening
External Corrosion: Soil related	Inferior/Substandard Material	Disturbed Thrust Blocks
Internal Corrosion	Mechanical Puncture Weld Failure	
Earthquake Break		

Street Damage? Yes No Outside Flooding? Yes No

Inside Flooding? Yes No Other Utility Damage? Yes No

Soil Type (circle one): Clay Gravel Rock Sand Silt Wet soil? Yes No

Corrosion Type (circle one): None Internal External Both

Repair Method (circle 1):

Bell clamp	Hydrant Replace	Hydrant Repair
Other	Repair clamp	Thrust block/restraint added
Replace section w/flex couplings	Repack lead joint	Repack rubber joint
Replace section w/cutting sleeve	Valve repair	Valve replace
Weld Patch		

HYDRANT TEST DATA SHEET

Optional input data for WPIPER

Link #: _____ Hydrant #: _____

Hydrant test #: _____ Date: _____

Pitot Model: _____

Nozzle inside Diameter, D (in): _____

Discharge coefficient, C: _____

Residual Pressure at Test Flow Rate, P_t (psi): _____

Test Flow Rate, Q_t (gpm):

$$Q_t = 29.8\,CD^2\sqrt{P_t}$$

Pressure at Discharge Gauge, P_f (psi): _____

Nominal Static Pressure before Test, P_s(psi): _____

Flow Rate at fire condition (gpm):

$$Q_f = Q_t \left(\frac{P_s - P_f}{P_s - P_t}\right)^{0.54}$$

Comments: _____

_____

_____

Appendix C: Hydrant (C-factor) Test Procedure

This Appendix contains a detailed procedure for performing C-factor tests. Additional information can be found in ETL 1110-2-297 and Walski (1984).

1. The equipment needed for determining C-factors in the field includes two pressure gauges, a Pitot gauge, a hydrant wrench, and miscellaneous fittings for gauge attachment. The test will involve a pipe section with three hydrants along its length. Pressure will be measured at the two test hydrants. The third hydrant will be opened (flowed). The hydrant to be flowed must be downstream of the two test hydrants, and an isolation valve must be shut downstream of the hydrant that will be opened. This will prevent water flow from both pipes connecting to the opened hydrant. In looped distribution systems, no services will be shut off using this method, although low service pressure will occur. Dead end branches may be tested without using an isolation valve. If the parallel pipe test method is used, the two gauges may be replaced with a differential pressure gauge with pressure snubbers and several lengths of hose.

2. If the parallel pipe method is used, no static pressure readings are needed. The differential pressure and flow (GPM) are the only required measurements. When using individual gauges, the first step is to attach the gauges to the test hydrants. This is usually done by mounting the gauge on a 2½-in. hydrant cap. When the gauge is attached, open the hydrant valve slowly. Dry barrel hydrants should be opened fully for pressure readings, as the drain openings are blocked when the valve is fully opened. Partially opening the valve will result in faulty readings and may undermine the soil beneath the hydrant. Wet barrel hydrants found in climates where freezing is rare need not be opened fully, but care should be taken when closing them to prevent gauge damage. A gauge cock or drain valve on the gauge connection can be used to protect gauges from over pressure during valve operation.

3. The static (no flow) pressure readings should be recorded on the Hydrant Test Data Sheet, to the nearest 0.5 psi. Any isolation valves used should be closed prior to taking any readings to reduce error.

4. The hydrant to be flowed is now opened. The hydrant valve may be opened fairly quickly. It will take several seconds for the flow to maximize. Record the pressures at the two test hydrants. Simultaneously, center the Pitot tube gauge in the discharge stream and take a pressure reading. Some Pitot gauges read directly in GPM based on a standard 2½-in. hydrant orifice. The Pitot reading must be given time to stabilize, as most gauges use a pressure snubber to reduce gauge flutter. Note that it is not necessary to fully open the hydrant being flowed. When using gauges with ± 0.5 psi accuracy, a differential pressure of 5 psi or more will give accurate C-factors. For long sections of small diameter pipe, 300-700 GPM may give good pressure drops. On 12-in. or larger pipes, over 1,000 GPM will be needed. Sometimes two hydrants must be flowed to create enough flow for significant pressure drops to occur. Two hydrants flowing will allow testing of pipes up to 24 in. in diameter. Testing larger pipes is impractical and of little value since the pipe wall roughness has less effect on flow capacity.

5. After the three pressure readings are taken, the hydrant being flowed can be closed slowly. Water hammer is possible, so care must be taken to close the hydrant slowly. The momentum of the water must be overcome gradually. To illustrate, the water in an 8-in. pipe flowing at 7 ft/second (1,000 GPM) in a half-mile long section has the same momentum as a 4,000-lb car traveling at 70 miles per hour. Neither should be stopped suddenly. Water temperature may be taken if additional accuracy is desired; however, viscosity difference affects the pressure loss very little at tap water temperatures.

6. The pressure test hydrants may now be closed and the pressure gauges removed. Any isolation valves used should now be opened and relocked or sealed if required. Tighten all hydrant caps to prevent vandalism or theft. Verify that the water released has drained properly and no damage was done.

7. The hydrant test should take only a short time, and full flow for only a minute is needed to take readings. The test crew may want to take pressure readings at two flow rates to check the test accuracy. Use the form given in Appendix B to calculate the Hazen-Williams C factor.

Appendix D: Sample WPIPER Reports

This Appendix contains samples of the following WPIPER 1.0 reports:

Page 1

SPECIFY REPORT (PIPE)
Filename: C:\EMS\WPIPER\WPIPER10\FTLEWIS
REPORT DATE: 1995.04.27 13:25:50
WPIPER (v. EMS 1.0)

LINK NUMBER	UP SYSTEM NODE	DOWN SYSTEM NODE	PIPE DIAMETER (ID,INCHES)	LENGTH (FT.)	INSTALLED "C" VALUE
100	10	11	12.0	620	120
101	11	12	6.0	760	120
102	12	14	6.0	1250	120
107	14	18	6.0	400	120
108	18	19	6.0	270	120
109	20	19	6.0	380	120
110	21	20	6.0	290	120
111	21	18	6.0	420	120
112	22	21	6.0	360	120
113	23	22	10.0	480	120
114	24	23	10.0	690	120
115	25	23	10.0	400	120
116	26	22	10.0	1110	120
117	11	24	12.0	930	120
118	24	25	12.0	300	120
119	25	26	12.0	380	120
120	27	26	12.0	120	120
121	28	27	12.0	480	120
122	29	28	12.0	130	120
123	30	29	12.0	1130	120
124	31	30	12.0	680	120
125	32	31	12.0	450	120
126	32	34	6.0	760	120
127	34	33	8.0	320	120
128	35	34	8.0	630	120
129	36	35	8.0	250	120
130	35	37	6.0	250	120
131	37	30	8.0	560	120
132	37	38	6.0	590	120
133	36	38	6.0	1000	120
134	38	39	6.0	290	120
135	39	11	6.0	300	120
137	41	40	6.0	130	120
138	40	28	6.0	280	120
139	29	41	6.0	280	120
506	54	32	12.0	1	100
507	55	36	12.0	1	100

-- End SPECIFY REPORT (PIPE) --

Page 1

SPECIFY REPORT (PIPE)
Filename: C:\EMS\WPIPER\WPIPER10\FTLEWIS
REPORT DATE: 1995.04.27 11:46:00
WPIPER (v. EMS 1.0)

LINK NUMBER	UP SYSTEM NODE	PIPE MATERIAL	WALL THICKNESS	CATHODIC PROTECTION (T/F)	DATE INSTALLED
100	10	CI	0.480	.F.	1940.01.01
101	11	CI	0.380	.F.	1940.01.01
102	12	CI	0.380	.F.	1940.01.01
107	14	CI	0.380	.F.	1940.01.01
108	18	CI	0.380	.F.	1940.01.01
109	20	CI	0.380	.F.	1940.01.01
110	21	CI	0.380	.F.	1940.01.01
111	21	CI	0.380	.F.	1940.01.01
112	22	CI	0.380	.F.	1940.01.01
113	23	CI	0.440	.F.	1940.01.01
114	24	CI	0.440	.F.	1940.01.01
115	25	CI	0.440	.F.	1940.01.01
116	26	CI	0.440	.F.	1940.01.01
117	11	CI	0.480	.F.	1940.01.01
118	24	CI	0.480	.F.	1940.01.01
119	25	CI	0.480	.F.	1940.01.01
120	27	CI	0.480	.F.	1940.01.01
121	28	CI	0.480	.F.	1940.01.01
122	29	CI	0.480	.F.	1940.01.01
123	30	CI	0.480	.F.	1940.01.01
124	31	CI	0.480	.F.	1940.01.01
125	32	CI	0.480	.F.	1940.01.01
126	32	CI	0.380	.F.	1940.01.01
127	34	CI	0.410	.F.	1940.01.01
128	35	CI	0.410	.F.	1940.01.01
129	36	CI	0.410	.F.	1940.01.01
130	35	CI	0.380	.F.	1940.01.01
131	37	CI	0.410	.F.	1940.01.01
132	37	CI	0.380	.F.	1940.01.01
133	36	CI	0.380	.F.	1940.01.01
134	38	CI	0.380	.F.	1940.01.01
135	39	CI	0.380	.F.	1940.01.01
137	41	CI	0.380	.F.	1940.01.01
138	40	CI	0.380	.F.	1940.01.01
139	29	CI	0.380	.F.	1940.01.01
506	54	CI	0.480	.F.	1940.01.01
507	55	CI	0.480	.F.	1940.01.01

-- End SPECIFY REPORT (PIPE) --

The following Data Validation Report shows a system in which no fixed grade NODES have been set. The third line of the report under the heading reports this error. The second page of the report states that the databases contain no bad values. This means that the data entered into the database makes up a good data set with NODES and LINKS all connecting as required. After running this report, NODEs 10, 33, 54, and 55 were set as fixed grade nodes (type 3) with estimated hydraulic grade line elevations (head in feet was set above the NODE elevation) estimated based on a knowledge of the system.

Page 1

AWADISO Data Validation Report
Filename: FTLWSBK
REPORT DATE: 1992.04.02 13:16:20
WPIPER (v. EMS 1.0)
Base Year used: 1980 Future Year used: 2002

Errors found in Hydraulic Network data.
AWADISO cannot be run using this data until errors are corrected.
No Constant Supply Node was specified.
See Bad Values at base of Link & Node tables.

Summary of Data Quantities:

# of Links = 37	# of Nodes = 30	# of Check Valves = 0
Pipes = 37	Inputs = 4	
Pumps = 0	Outputs = 26	
PRVs = 0	Tanks = 0	
	Reservoirs = 0	

PIPE DATA TABLE:

Link #	Up. Node	Down. Node	Dia. (in.)	Length (ft.)	Installed "C"	Date Installed	Pipe Identifier	Check Valve
100	10	11	12.0	620	82	1960.01.01		
101	11	12	6.0	760	27	1960.01.01		
103	12	14	6.0	1250	27	1960.01.01		
107	14	18	6.0	400	65	1960.01.01		
108	18	19	6.0	270	65	1960.01.01		
109	20	19	6.0	380	65	1960.01.01		
110	21	20	6.0	290	65	1960.01.01		
111	21	18	6.0	420	65	1960.01.01		
110	22	21	6.0	360	65	1960.01.01		
113	23	22	10.0	480	116	1960.01.01		
114	24	23	20.0	690	116	1960.01.01		
115	22	23	10.0	400	116	1960.01.01		
116	26	22	10.0	1110	116	1960.01.01		
117	11	24	12.0	930	82	1960.01.01		
118	24	25	12.0	300	104	1960.01.01		
119	25	26	12.0	380	104	1960.01.01		
120	27	26	12.0	120	104	1960.01.01		
121	28	27	12.0	480	93	1960.01.01		
122	29	28	12.0	130	93	1960.01.01		
123	30	29	12.0	1130	93	1960.01.01		
124	31	30	12.0	680	93	1960.01.01		
125	32	31	12.0	450	93	1960.01.01		
126	32	34	6.0	760	58	1960.01.01		
127	34	33	8.0	320	48	1960.01.01		
128	35	34	8.0	630	48	1960.01.01		
129	36	35	8.0	250	48	1960.01.01		
130	35	37	6.0	250	43	1960.01.01		
131	37	30	8.0	560	48	1960.01.01		
132	37	38	6.0	590	43	1960.01.01		
133	36	38	6.0	1000	58	1960.01.01		
134	38	39	6.0	290	43	1960.01.01		
135	35	11	6.0	300	43	1960.01.01		

Page 2

AWADISO Data Validation Report
Filename: FTLWSBK
REPORT DATE: 1992.04.02 13:16:20
WPIPER (v. EMS 1.0)
Base Year used: 1980 Future Year used: 2002

PIPE DATA TABLE:

Link #	Up. Node	Down. Node	Dia. (in.)	Length (ft.)	Installed "C"	Date Installed	Pipe Identifier	Check Valve
137	41	40	6.0	130	65	1960.01.01		
138	40	28	6.0	280	65	1960.01.01		
139	29	41	6.0	280	65	1960.01.01		
506	54	32	12.0	1	100	1960.01.01		
507	55	36	12.0	1	100	1960.01.01		

Bad Values: None.

Notes: 1. If Aging Data is sent to AWADISO, a calculated Base Year "C" is sent as the Hazen-Williams Coefficient. Otherwise, the Installed "C" value is sent.
2. Check Valve refers to the number of CHECK valves (WPIPER appurtenance types CK & RP) on the pipe link.

PUMP DATA TABLE:

No pumps in system.

PRV DATA TABLE:

No PRVs in system.

CHECK VALVE DATA TABLE:

No check valves in system.

NODE DATA TABLE:

Node #	Elevation of center line at node(ft.)	Node Type	Domestic Demand	Fire Demand	Water Surface elev. (ft.)	Output (GPM)	# Links attached
10	257.0	1	838	0	0.0	-838	1
11	258.0	2	24	0	0.0	24	4
12	267.0	2	0	0	0.0		2
14	272.0	2	20	0	0.0	20	2
18	266.0	2	0	0	0.0		3
19	269.0	2	0	500	0.0	500	2
20	260.0	2	30	500	0.0	530	2
21	255.0	2	0	0	0.0		3
22	255.0	2	0	0	0.0		3
23	255.0	2	18	0	0.0	18	3
24	255.0	2	0	0	0.0		3

Page 3

AWADISO Data Validation Report
Filename: FTLWSBK
REPORT DATE: 1992.04.02 13:16:20
WPIPER (v. EMS 1.0)
Base Year used: 1980 Future Year used: 2002

NODE DATA TABLE:

Node #	Elevation of center line at node(ft.)	Node Type	Domestic Demand	Fire Demand	Water Surface elev. (ft.)	Output (GPM)	# Links attached
25	255.0	2	18	0	0.0	18	3
26	256.0	2	0	0	0.0		3
27	256.0	2	0	0	0.0		2
28	256.0	2	100	500	0.0	600	3
29	254.0	2	0	0	0.0		3
30	250.0	2	25	0	0.0	25	3
31	255.0	1	450	0	0.0	-450	2
32	260.0	2	20	0	0.0	20	3
33	263.0	2	39	0	0.0	39	1
34	259.0	2	40	0	0.0	40	3
35	255.0	2	22	0	0.0	22	4
36	256.0	2	0	0	0.0		3
37	255.0	2	28	0	0.0	28	3
38	255.0	2	22	0	0.0	22	3
39	259.0	2	0	0	0.0		1
40	255.0	2	0	0	0.0		2
41	255.0	2	12	0	0.0	12	2
54	260.0	1	425	0	0.0	-425	1
55	256.0	1	206	0	0.0	-206	1

Bad Values: None.

NOTES:
1. Node Type : 1 = INPUT, 2 = OUTPUT, 3 = TANK, 4 = RESERVOIR
2. Output (GPM) value is sent to AWADISO if Node Type is 1 or 2. This is the sum of Domestic plus Fire Demands. If Node Type is 1 (INPUT), it is shown as negative output.
3. If a node is not assigned to a link, AWADISO will ignore it.

PIPE AGING DATA TABLE:

Link #	Age (Y/N)	Material Code	Lining Code	Aging Method	ALPHA Value	HAZE "C"	Age of HAZE "C"	HAZE: Avg.Dia.	LANGelier Index	Water Quality	Base Year "C
100	no	CI-ferrous	CO		0.00000					FTORD	82
101	no	CI-ferrous	CO		0.00000					FTORD	27
103	no	CI-ferrous	CO		0.00000					FTORD	27
107	no	CI-ferrous	CO		0.00000					FTORD	65
108	no	CI-ferrous	CO		0.00000					FTORD	65
109	no	CI-ferrous	CO		0.00000					FTORD	65
110	no	CI-ferrous	CO		0.00000					FTORD	65
111	no	CI-ferrous	CO		0.00000					FTORD	65
112	no	CI-ferrous	CO		0.00000					FTORD	65
113	no	CI-ferrous	CO		0.00000					FTORD	116
114	no	CI-ferrous	CO		0.00000					FTORD	116

Page 4

AWADISO Data Validation Report
Filename: FTLWSBK
REPORT DATE: 1992.04.02 13:16:20
WPIPER (v. EMS 1.0)
Base Year used: 1980 Future Year used: 2002

PIPE AGING DATA TABLE:

Link #	Age (Y/N)	Material Code	Lining Code	Aging Method	ALPHA Value	HAZE "C"	Age of HAZE "C"	HAZE: Avg.Dia.	LANGelier Index	Water Quality	Base Year "C"
115	no	CI-ferrous	CO		0.00000					FTORD	116
116	no	CI-ferrous	CO		0.00000					FTORD	116
117	no	CI-ferrous	CO		0.00000					FTORD	82
118	no	CI-ferrous	CO		0.00000					FTORD	104
119	no	CI-ferrous	CO		0.00000					FTORD	104
120	no	CI-ferrous	CO		0.00000					FTORD	104
121	no	CI-ferrous	CO		0.00000					FTORD	93
122	no	CI-ferrous	CO		0.00000					FTORD	93
123	no	CI-ferrous	CO		0.00000					FTORD	93
124	no	CI-ferrous	CO		0.00000					FTORD	93
125	no	CI-ferrous	CO		0.00000					FTORD	93
126	no	CI-ferrous	CO		0.00000					FTORD	58
127	no	CI-ferrous	CO		0.00000					FTORD	48
128	no	CI-ferrous	CO		0.00000					FTORD	48
129	no	CI-ferrous	CO		0.00000					FTORD	48
130	no	CI-ferrous	CO		0.00000					FTORD	43
131	no	CI-ferrous	CO		0.00000					FTORD	48
132	no	CI-ferrous	CO		0.00000					FTORD	43
133	no	CI-ferrous	CO		0.00000					FTORD	58
134	no	CI-ferrous	CO		0.00000					FTORD	43
135	no	CI-ferrous	CO		0.00000					FTORD	43
137	no	CI-ferrous	CO		0.00000					FTORD	65
138	no	CI-ferrous	CO		0.00000					FTORD	65
139	no	CI-ferrous	CO		0.00000					FTORD	65
506	no	CI-ferrous	CO		0.00000					FTORD	100
507	no	CI-ferrous	CO		0.00000					FTORD	100

Bad Values: None.

Notes:
1. Aging Data will be sent to AWADISO for pipe links that satisfy
   (a) Material Code specifies a ferrous material
   (as designated in WPIPER's Material Code database)
   (b) Lining Code specifies an unlined pipe (blank or "NO")
   (c) Valid Aging Method specified: A - ALPHA, H - HAZE, L - LANGELIER
   (d) A positive Alpha value calculated by WPIPER from the aging data supplied.

2. WPIPER calculates the ALPHA value and, from that, the Base Year "C" for all aging methods according to the same formulas employed by AWADISO. These calculated ALPHA values are passed to AWADISO.
   (a) ALPHA method
   - the Alpha value specified by the user is sent to AWADISO. If AWADISO detects an out-of-range Alpha, AWADISO will not age that pipe.
   (b) HAZE method
   - the Alpha value is set to 0 if the recorded "C" is > 137, otherwise, it is calculated according to:

Page 5

AWADISO Data Validation Report
Filename: FTLWSBK
REPORT DATE: 1992.04.02 13:16:20
WPIPER (v. EMS 1.0)
Base Year used: 1980 Future Year used: 2002

$$ALPHA = ((AGE\ H\ DIAM /12) * 10^{\wedge ((18-AGE\ H\ C) /37.2) - 0.0006) /AGE\ H\ AGE}$$

Non-positive values of "C", age, or diameter are trapped by WPIPER and no calculation is made.

(c) LANG method
- the Alpha value is set to 0 if the Langelier Index is non-negative, otherwise, it is calculated according to:

$$ALPHA = 10^{\wedge (-4.08 - 0.38 * AGE\ LANG)}$$

The main reason for sending the Alpha value for all 3 methods is the fact that AWADISO uses one Base Year while WPIPER allows a different Date of Installation to be recorded for each link. Hence, to provide AWADISO with consistent C values for the Base Year, WPIPER needs to calculate them. For a pipe link installed in 1955 (C = 120), measured again in 1982 (C = 100), the HAZE method would be utilized to calculate the aging rate (Alpha factor). If the Base Year sent was 1980, AWADISO would calculate an aging rate based on a calculated Base Year C and a recorded C over only two years. WPIPER can achieve a more accurate Alpha value by employing the HAZE formula over 27 years. And, in the event that a recorded C is prior to the Base Year (e.g. 1978), an Alpha factor could be calculated by WPIPER but not by AWADISO. It should also be noted that AWADISO saves pipe aging data by Alpha value only and not by method input.

3. If invalid aging data is found, the Alpha value will not be calculated and the Base Year "C" will be set to an error value according to the following:
   -1 : Invalid Installed "C" value
   -2 : Link's Date Installed is later than the Base Year
   -3 : LANG aging method specified and link refers to an invalid Water Quality.
   -4 : HAZE aging method specified and invalid data accompanies it.

   Invalid aging data must be corrected before it can be sent to AWADISO.

-- End AWADISO Data Validation Report --

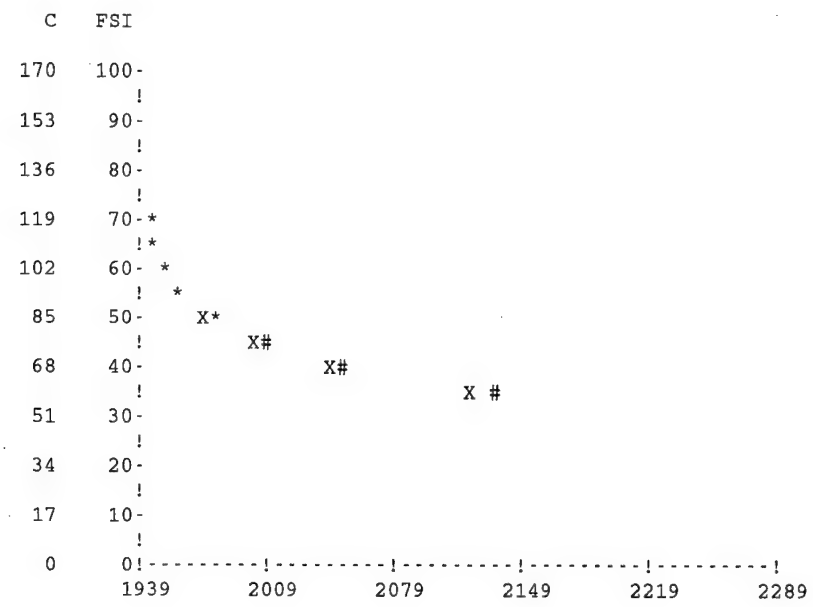
Page 1

FSI REPORT
Filename: FTLEWIS
REPORT DATE: 1995.04.27 11:47:50
WPIPER (v. EMS 1.0)

LINK NUMBER	: 100	PIPE IDENTIFIER	:
PIPE SIZE - ID (inch)	: 12.0		
YEAR INSTALLED	: 1940	INSTALLED C VALUE	: 120
PREDICTED (FSI<=30)	: None.	LAST MEASURED C VALUE	: 82 in 1989

Method of C value calculation : HAZE of diameter of 12.0, age of 49, C value of 82

Predicted ALPHA : 0.0004
Actual ALPHA : 0.0004



X Prediction
* Actual
# Extrapolation

FSI REPORT
Filename: FTLEWIS
REPORT DATE: 1995.04.27 11:47:50
WPIPER (v. EMS 1.0)

LINK NUMBER : 100

GRAPH TABLE

FSI YEAR	CALCULATED FSI
1940	71
1945	64
1950	60
1955	57
1960	55
1965	53
1970	52
1975	51
1980	49
1985	48
1990	47
1995	47
2000	46
2005	45
2010	45
2015	44
2020	43
2025	43
2030	42
2035	42
2040	41
2045	41
2050	40
2055	40
2060	40
2065	39
2070	39
2075	39
2080	38
2085	38
2090	38
2095	37
2100	37
2105	37
2110	36
2115	36
2120	36
2125	36
2130	35
2135	35

Page 3

FSI REPORT
Filename: FTLEWIS
REPORT DATE: 1995.04.27 11:47:50
WPIPER (v. EMS 1.0)

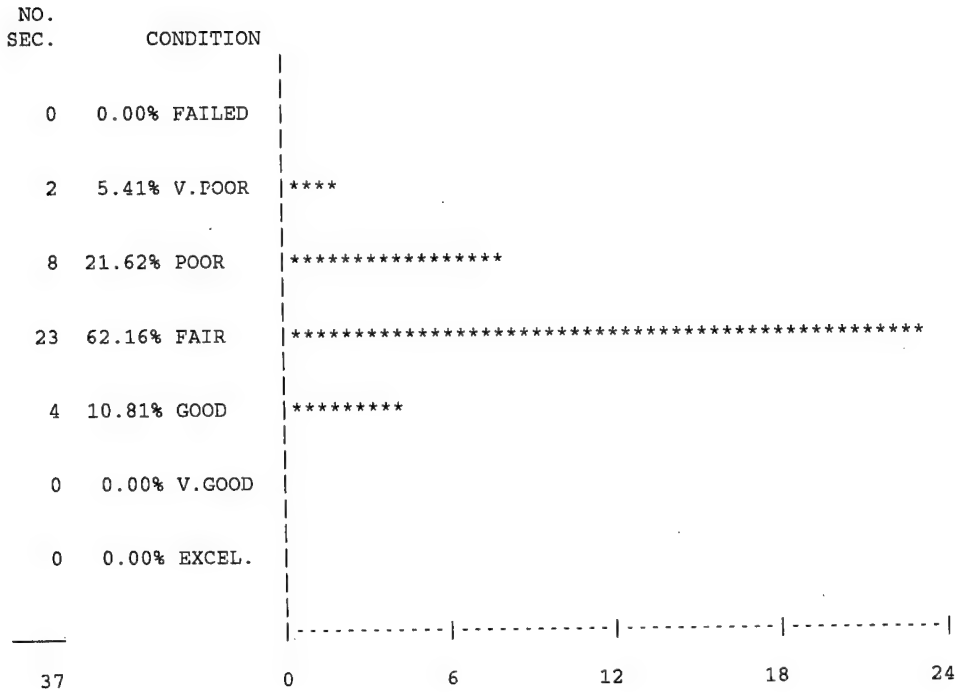
LINK NUMBER : 100

GRAPH TABLE

FSI YEAR	CALCULATED FSI
2140	35
2145	35
2150	34
2155	34
2160	34
2165	34
2170	34
2175	33
2180	33
2185	33
2190	33
2195	33
2200	33
2205	32
2210	32
2215	32
2220	32
2225	32
2230	31
2235	31

-- End Flow Status Index Report --

CONDITION FREQUENCY REPORT
Filename: FTLEWIS
REPORT DATE: 1995.04.27 11:48:40
WPIPER (v. EMS 1.0)



-- End CONDITION FREQUENCY Report --

Page 1

PRIORITY RANKING REPORT
Filename: FTLEWIS
REPORT DATE: 1995.04.27 11:49:10
WPIPER (v. EMS 1.0)

RANK	LINK NUMBER	FSI	DIAMETER
1	101	21	6.0
2	102	21	6.0
3	130	31	6.0
4	132	31	6.0
5	134	31	6.0
6	135	31	6.0
7	127	31	8.0
8	128	31	8.0
9	129	31	8.0
10	131	31	8.0
11	126	39	6.0
12	133	39	6.0
13	506	41	12.0
14	507	41	12.0
15	107	44	6.0
16	108	44	6.0
17	109	44	6.0
18	110	44	6.0
19	111	44	6.0
20	112	44	6.0
21	137	44	6.0
22	138	44	6.0
23	139	44	6.0
24	100	46	12.0
25	117	46	12.0
26	121	53	12.0
27	122	53	12.0
28	123	53	12.0
29	124	53	12.0
30	125	53	12.0
31	118	58	12.0
32	119	58	12.0
33	120	58	12.0
34	113	65	10.0
35	114	65	10.0
36	115	65	10.0
37	116	65	10.0

-- End PRIORITY RANKING Report --

Page 1

C Value Worksheet Report
Filename: FTLEWIS
REPORT DATE: 1995.04.27 11:49:20
WPIPER (v. EMS 1.0)
Base Year used: 1994 Future Year used: 2004

NOTE: This worksheet is provided to allow assigning "C" values to pipe links to aid in system calibration.

Link Number	Material Code	Date Of Installation	Installed "C" value	Current "C" value	Base Year "C" value	Future Year "C" value	Proposed "C" value
100	CI	1940.01.01	120	79	80	77	_____
101	CI	1940.01.01	120	36	37	34	_____
102	CI	1940.01.01	120	36	37	34	_____
107	CI	1940.01.01	120	74	74	71	_____
108	CI	1940.01.01	120	74	74	71	_____
109	CI	1940.01.01	120	74	74	71	_____
110	CI	1940.01.01	120	74	74	71	_____
111	CI	1940.01.01	120	74	74	71	_____
112	CI	1940.01.01	120	74	74	71	_____
113	CI	1940.01.01	120	110	110	109	_____
114	CI	1940.01.01	120	110	110	109	_____
115	CI	1940.01.01	120	110	110	109	_____
116	CI	1940.01.01	120	110	110	109	_____
117	CI	1940.01.01	120	79	80	77	_____
118	CI	1940.01.01	120	99	99	97	_____
119	CI	1940.01.01	120	99	99	97	_____
120	CI	1940.01.01	120	99	99	97	_____
121	CI	1940.01.01	120	90	90	87	_____
122	CI	1940.01.01	120	90	90	87	_____
123	CI	1940.01.01	120	90	90	87	_____
124	CI	1940.01.01	120	90	90	87	_____
125	CI	1940.01.01	120	90	90	87	_____
126	CI	1940.01.01	120	67	67	65	_____
127	CI	1940.01.01	120	53	53	50	_____
128	CI	1940.01.01	120	53	53	50	_____
129	CI	1940.01.01	120	53	53	50	_____
130	CI	1940.01.01	120	52	52	50	_____
131	CI	1940.01.01	120	53	53	50	_____
132	CI	1940.01.01	120	52	52	50	_____
133	CI	1940.01.01	120	67	67	65	_____
134	CI	1940.01.01	120	52	52	50	_____
135	CI	1940.01.01	120	52	52	50	_____
137	CI	1940.01.01	120	74	74	71	_____
138	CI	1940.01.01	120	74	74	71	_____
139	CI	1940.01.01	120	74	74	71	_____
506	CI	1940.01.01	100	69	69	66	_____
507	CI	1940.01.01	100	69	69	66	_____

-- End C VALUE WORKSHEET Report --

Page 1

WATER QUALITY REPORT
Filename: FTLEWIS
REPORT DATE: 1995.04.27 11:49:40
WPIPER (v. EMS 1.0)

WATER IDENTIFICATION : FTLEWIS
Description: Ft. Lewis Distribution

pH 6.40 Temperature(F)	54.00	Silicate (mg/l)	10.00
Oxygen (mg/l)	7.00	Sulfate (mg/l)	11.00
Carbon Dioxide (mg/l)	19.00	Sulfide (mg/l)	0.000
Aluminum (mg/l)	0.00	Carbonate Hardness (mg/l)	0.00
Copper (mg/l)	0.00	Total Hardness (mg/l)	50.00
Iron (mg/l)	0.05	Methyl Orange Alkalinity (mg/l)	0.00
Magnesium (mg/l)	4.50	Phenolphthalein Alkalinity (mg/l)	0.00
Manganese (mg/l)	0.000	Hydroxide Alkalinity (mg/l)	0.00
Sodium (mg/l)	5.80	Bicarbonate Alkalinity (mg/l)	0.00
Tin (mg/l)	0.00	Carbonate Alkalinity (mg/l)	0.00
Zinc (mg/l)	0.00	Total Dissolved Solids (mg/l)	58.00
Chloride (mg/l)	5.00	Conductivity (micromhos)	0.00
Chlorine (mg/l)	0.00		
Fluoride (mg/l)	0.00	Langelier Index	-2.40
Nitrogen (mg/l)	0.00	Ryznar Index	11.40
Phosphates (mg/l)	0.00	Aggressiveness Index	0.00

WATER IDENTIFICATION : FTORD
Description: Ft. Ord Distribution

pH 7.50 Temperature(F)	65.00	Silicate (mg/l)	35.00
Oxygen (mg/l)	7.00	Sulfate (mg/l)	83.00
Carbon Dioxide (mg/l)	13.00	Sulfide (mg/l)	0.000
Aluminum (mg/l)	0.00	Carbonate Hardness (mg/l)	0.00
Copper (mg/l)	0.07	Total Hardness (mg/l)	188.00
Iron (mg/l)	0.08	Methyl Orange Alkalinity (mg/l)	0.00
Magnesium (mg/l)	18.00	Phenolphthalein Alkalinity (mg/l)	0.00
Manganese (mg/l)	0.010	Hydroxide Alkalinity (mg/l)	0.00
Sodium (mg/l)	45.00	Bicarbonate Alkalinity (mg/l)	0.00
Tin (mg/l)	0.00	Carbonate Alkalinity (mg/l)	0.00
Zinc (mg/l)	0.02	Total Dissolved Solids (mg/l)	431.00
Chloride (mg/l)	90.00	Conductivity (micromhos)	0.00
Chlorine (mg/l)	0.00		
Fluoride (mg/l)	0.00	Langelier Index	-0.22
Nitrogen (mg/l)	0.00	Ryznar Index	7.94
Phosphates (mg/l)	0.00	Aggressiveness Index	0.00

Page 2

WATER QUALITY REPORT
Filename: FTLEWIS
REPORT DATE: 1995.04.27 11:49:40
WPIPER (v. EMS 1.0)

WATER IDENTIFICATION : SAMPLE
Description: Sample Water Data

pH 7.00 Temperature(F)	70.00	Silicate (mg/l)	0.00
Oxygen (mg/l)	0.00	Sulfate (mg/l)	98.00
Carbon Dioxide (mg/l)	0.00	Sulfide (mg/l)	0.000
Aluminum (mg/l)	0.00	Carbonate Hardness (mg/l)	212.00
Copper (mg/l)	0.02	Total Hardness (mg/l)	0.00
Iron (mg/l)	0.01	Methyl Orange Alkalinity (mg/l)	0.00
Magnesium (mg/l)	18.00	Phenolphthalein Alkalinity (mg/l)	0.00
Manganese (mg/l)	0.000	Hydroxide Alkalinity (mg/l)	0.00
Sodium (mg/l)	46.00	Bicarbonate Alkalinity (mg/l)	0.00
Tin (mg/l)	0.00	Carbonate Alkalinity (mg/l)	158.00
Zinc (mg/l)	0.00	Total Dissolved Solids (mg/l)	427.00
Chloride (mg/l)	46.00	Conductivity (micromhos)	0.00
Chlorine (mg/l)	0.00		
Fluoride (mg/l)	0.00	Langelier Index	0.00
Nitrogen (mg/l)	0.00	Ryznar Index	0.00
Phosphates (mg/l)	0.00	Aggressiveness Index	0.00

-- End WATER QUALITY Report --

ECON1 REPORT
REPORT DATE: 1995.04.27 11:55:40

PROJECTED COST ANALYSIS (DETAIL)

Section ID :LINK 100

Section Length : 620 feet
Interest Rate : 10.00 % Inflation Rate : 4.00 %

Alternative : REPLACE WITH PLASTIC
Life of Alternative : 50

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
REMOVE ASPHALT	1995	15000.00	15000.00
EXCAVATE TRENCH	1995	30000.00	30000.00
INSTALL PIPE AND BACKFILL	1995	50000.00	50000.00
REPAVE	1995	15000.00	15000.00
	Total:	110000.00	110000.00

Initial Cost ($) : 110000.00
Present Value ($) : 110000.00
Equivalent Uniform Annual Cost (EUAC) : 11094.51
EUAC per Linear Foot : 17.89

-- End DETAIL Economic Report --

ECON1 REPORT
REPORT DATE: 1995.04.27 11:56:00

PROJECTED COST ANALYSIS (SUMMARY)

Section ID :LINK 100

Section Length : 620 feet
Interest Rate : 10.00 % Inflation Rate : 4.00 %

Alternative : REPLACE WITH PLASTIC
Life of Alternative : 50
Initial Cost ($) : 110000.00
Present Value ($) : 110000.00
Equivalent Uniform Annual Cost (EUAC) : 11094.51
EUAC per Linear Foot : 17.89
-- End SUMMARY Economic Report --

ECON1 REPORT
REPORT DATE: 1995.04.27 11:58:00

PROJECTED COST ANALYSIS (DETAIL)

Section ID :100

Section Length : 620 feet
Interest Rate : 10.00 % Inflation Rate : 4.00 %

Alternative : PRESSURE CLEANING
Life of Alternative : 50

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
PRESSURE CLEAN	1995	20000.00	20000.00
	Total:	20000.00	20000.00
REPAIR LEAKS	2000	2000.00	1510.89
	Total:	2000.00	1510.89
PRESSURE CLEAN	2005	20000.00	11413.97
REPAIR LEAKS	2005	2000.00	1141.40
	Total:	22000.00	12555.36
REPAIR LEAKS	2010	2000.00	862.26
	Total:	2000.00	862.26
PRESSURE CLEAN	2015	20000.00	6513.93
REPAIR LEAKS	2015	2000.00	651.39
	Total:	22000.00	7165.32
REPAIR LEAKS	2020	2000.00	492.09
	Total:	2000.00	492.09
PRESSURE CLEAN	2025	20000.00	3717.49
REPAIR LEAKS	2025	2000.00	371.75
	Total:	22000.00	4089.24
REPAIR LEAKS	2030	2000.00	280.84
	Total:	2000.00	280.84
PRESSURE CLEAN	2035	20000.00	2121.56
REPAIR LEAKS	2035	2000.00	212.16
	Total:	22000.00	2333.72
REPAIR LEAKS	2040	2000.00	160.27
	Total:	2000.00	160.27

Initial Cost ($) : 20000.00
Present Value ($) : 49450.00
Equivalent Uniform Annual Cost (EUAC) : 4987.49
EUAC per Linear Foot : 8.04

-- End DETAIL Economic Report --

ECON1 REPORT
REPORT DATE: 1995.04.27 11:58:10

PROJECTED COST ANALYSIS (SUMMARY)

Section ID :100

Section Length : 620 feet
Interest Rate : 10.00 % Inflation Rate : 4.00 %

Alternative : PRESSURE CLEANING
Life of Alternative : 50
Initial Cost ($) : 20000.00
Present Value ($) : 49450.00
Equivalent Uniform Annual Cost (EUAC) : 4987.49
EUAC per Linear Foot : 8.04

-- End SUMMARY Economic Report --

The report on the following pages is the hydraulic analysis output generated from the preceding data where all pipe sections have been aged to the year 2000 using the "HAZE" method.

Page 1

AWADISO REPORT
Filename: FTLWSBK
REPORT DATE: 1992.04.02 16:09:50
WPIPER (v. EMS 1.0)
Data saved in files 92040203.AWA & 92040203.AGE

NODE DATA

NODE	ELEVATION	OUTPUT	E.G.L.	PR.HEAD	PRESSURE	
10	257.0	-743	411.0	154.0	66.7	SUPPLY
11	258.0	24	408.0	150.0	65.0	
12	267.0		358.2	91.2	39.5	
14	272.0	20	276.3	4.3	1.9	
18	266.0		274.0	8.0	3.5	
19	269.0	500	253.3	-15.7	-6.8	
20	260.0	530	253.9	-6.1	-2.6	
21	255.0		293.0	38.0	16.5	
22	255.0		402.8	147.8	64.0	
23	255.0	18	404.1	149.1	64.6	
24	255.0		404.1	149.1	64.6	
25	255.0	18	404.1	149.1	64.6	
26	256.0		404.1	148.1	64.2	
27	256.0		404.1	148.1	64.2	
28	256.0	600	404.3	148.3	64.3	
29	254.0		404.8	150.8	65.3	
30	250.0	25	409.1	159.1	69.0	
31	255.0	-450	411.6	156.6	67.8	
32	260.0	20	412.0	152.0	65.9	
33	263.0	-23	411.0	148.0	64.1	SUPPLY
34	259.0	40	410.9	151.9	65.8	
35	255.0	22	410.8	155.8	67.5	
36	256.0		412.0	156.0	67.6	
37	255.0	28	409.7	154.7	67.0	
38	255.0	22	410.3	155.3	67.3	
39	259.0		410.3	151.3	65.6	
40	255.0		404.5	149.5	64.8	
41	255.0	12	404.5	149.5	64.8	
54	260.0	-475	412.0	152.0	65.9	SUPPLY
55	256.0	-187	412.0	156.0	67.6	SUPPLY

LINK DATA HAZEN WILLIAMS COEFFICIENTS ARE FOR YEAR 2002

LINK	NODE	NODE	DIAMETER	LENGTH	COEF	FLOW	VELOCITY	HEADLOSS
100	10	11	12.0	620.0	68	743	2.1	3.0
101	11	12	6.0	760.0	18	129	1.5	49.8
103	12	14	6.0	1250.0	18	129	1.5	81.9
107	14	18	6.0	400.0	56	109	1.2	2.3
108	18	19	6.0	270.0	56	437	5.0	20.7
109	20	19	6.0	380.0	56	57	0.6	0.7
110	21	20	6.0	290.0	56	593	6.7	39.1
111	21	18	6.0	420.0	56	329	3.7	19.0
112	22	21	6.0	360.0	56	921	10.5	109.8
113	23	22	10.0	480.0	116	563	2.3	1.3

AWADISO REPORT
Filename: FTLWSBK
REPORT DATE: 1992.04.02 16:09:50
WPIPER (v. EMS 1.0)
Data saved in files 92040203.AWA & 92040203.AGE

LINK DATA HAZEN WILLIAMS COEFFICIENTS ARE FOR YEAR 2002

LINK	NODE	NODE	DIAMETER	LENGTH	COEF	FLOW	VELOCITY	HEADLOSS
114	24	23	20.0	690.0	116	520	0.5	0.1
115	25	23	10.0	400.0	116	60	0.2	0.0
116	26	22	10.0	1110.0	116	359	1.5	1.3
117	11	24	12.0	930.0	68	676	1.9	3.8
118	24	25	12.0	300.0	104	156	0.4	0.0
119	25	26	12.0	380.0	104	78	0.2	0.0
120	27	26	12.0	120.0	104	281	0.8	0.0
121	28	27	12.0	480.0	93	281	0.8	0.2
122	29	28	12.0	130.0	93	854	2.4	0.5
123	30	29	12.0	1130.0	93	893	2.5	4.4
124	31	30	12.0	680.0	93	861	2.4	2.4
125	32	31	12.0	450.0	93	411	1.2	0.4
126	32	34	6.0	760.0	49	44	0.5	1.1
127	33	34	8.0	320.0	37	23	0.1	0.1
128	34	35	8.0	630.0	37	27	0.2	0.1
129	36	35	8.0	250.0	37	138	0.9	1.2
130	35	37	6.0	250.0	34	58	0.7	1.1
131	37	30	8.0	560.0	37	57	0.4	0.5
132	38	37	6.0	590.0	34	27	0.3	0.7
133	36	38	6.0	1000.0	49	49	0.6	1.7
134	39	38	6.0	290.0	34	0	0.0	0.0
135	35	11	6.0	300.0	34	86	1.0	2.8
137	41	40	6.0	130.0	56	27	0.3	0.1
138	40	28	6.0	280.0	50	27	0.3	0.2
139	29	41	6.0	280.0	56	39	0.4	0.2
506	54	32	12.0	1.0	100	475	1.3	0.0
507	55	36	12.0	1.0	100	187	0.5	0.0

-- End AWADISO Report --

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